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TROPICAL FIBRES

Their Production and

ECONOMIC EXTRACTION

BY E. G. SQUIER.

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TROPICAL FIBRES:

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Their Production

AND

ECONOMIC EXTRACTION.

BY E. G. SQUIER,

FORMERLY MINISTER OF THE UNITED STATES IN CENTRAL AMERICA ETC.

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INTRODUCTION.

No person from northern latitudes can long reside in tropical countries, particularly in tropical America, without being struck with the number and variety of *endogenous* plants, such as the agaves, pine-apples, plantains, and palms, which form a characteristic and, to northern eyes, a novel feature in every landscape. If of an observant and inquiring turn of mind, the traveller will soon be brought to reflect on the economic value of these plants, and their thousand useful applications in supplying human wants. He will discover that they not only furnish staple articles of food, oil, and refreshing as well as intoxicating drinks, but also that they are the productive sources of valuable fibres, of every degree of fineness and strength, and fit for the most delicate tissues as well as for the strongest cables. He will find that the hammock in which he reclines is netted from a material almost as fine and soft as silk, and will probably be surprised to learn that it is supplied from the leaves of the wild pineapple, which he sees everywhere forming the hedges of enclosures, and scattered thickly through the forests. He will find the native boats rigged with cordage of superior description, and will be told that it has been procured from the agaves or *hennequins*, of which he will observe a small, perennial patch, with their green, fleshy leaves, growing by the side of almost every hut. Or, if in Mexico, he will

receive his passport on paper of surprising toughness and durability, made from the leaves of the *maguey*—the juice of which, supplying here the place of beer, cider, and more potent whiskey, is sold in the shops over the way, under the name of *pulque*. Or if, in the East Indies, he desires to send home some souvenir of his travels, he will select from the stock of an itinerant pedlar, a handkerchief of gossamer-like texture, almost as fine and as delicate as that which the spider weaves, made from the fibres of the leaves of the pineapple plant, the fruit of which he ate for his dessert. If in Manilla, he will find ships of all nations filling out their cargoes with bales of excellent fibres, which he will mistake for hemp or flax, but which he will ascertain, on inquiry, are extracted from the stalks of the plantain—the forests of which, with their broad leaves, shadow over every path and by-road of the island.

And if our traveller be well-informed as to the wants of manufactures and the arts, he will wonder how it is that the acknowledged and increasing deficiency in the world's supply of fibrous materials, has not been filled from the numerous and prolific sources which he sees everywhere around him. He will, perhaps, be induced to inquire why it is that the millions of plantain trees which are cut down throughout tropical America, after having yielded their fruit, are suffered to rot on the ground, instead of being utilized for the excellent fibres with which they are lined. He will ask why the countless agaves, which sometimes surround him like forests, and the myriads of wild-pine plants which throng the woods, and invade every abandoned field, are allowed to send out their fibre-stuffed leaves to flourish and decay, while the world clamors for an increased supply of fibrous materials?

Such at least, were the inquiries which pressed on my mind during my residence in tropical America. I saw around me

abundant, I had almost said infinite sources, from which to supply the existing deficiencies of the world and its future demands in respect of vegetable fibres. I asked myself, wonderingly, "Why are not all these fibre-bearing plants with which the country teems, in some way utilized?" But the question did not recur, after I came to learn the rude, imperfect, and laborious processes by which the relatively small quantity of fibres produced for local use and export is extracted.

I saw the native laborers at their work, slowly removing the pulpy and vascular portions of the agaves or *hennequins*, with a triangular scraper, or a blunted knife, leaf by leaf, and ascertained that a few pounds of fibres, imperfectly cleaned, formed the total reward of a long day's toil. I turned away from the patient Indian laborer with a smile, half of pity, half of contempt, and asked my friend, the American merchant and planter, who had lived for many years in the country, "Why don't you import proper machinery for doing this simple work, and thus make a fortune out of tropical fibres?" "Because," was his answer, "there is no such machinery to be had! I long ago sent to the United States, to England and France, and even to the Philippine Islands, where ten millions of dollars' worth of plantain fibres are extracted annually, and found that no machinery suited to the purpose has yet been invented. Everywhere, as far as I can learn, throughout tropical America, and the East Indies as well, the process of extracting these kinds of fibres, is substantially that which you see practiced by yonder Indian."

I was incredulous as to my friend's assertion, and when I returned to the United States I inquired for myself, but only to find his statement confirmed. I ascertained that although various machines had been devised for the purpose of cleaning the fibres of the pine-apple plants, the agaves, and plantains,

economically and rapidly, none had succeeded in practice. And I was compelled to give up some half-formed plans which I had entertained of setting up a machine somewhere in Central America, for the purpose of "making a fortune out of vegetable fibres," as I had advised my friend to do, years before. My interest in the subject, however, never ceased, and I did not entirely relinquish the notion, that sooner or later some rapid and easy method of extracting the fibres of the various tropical plants to which I have referred, would be discovered. I therefore allowed no inventions, claiming to accomplish this purpose, to escape my attention; but until recently none combining the essential requisites of cheapness, simplicity, rapidity, and efficiency, fell under my observation. A machine has now, however, been invented and put in operation, which, in my opinion, combines the desired conditions, and which I have little doubt is destined to augment very largely the present supply of tropical fibres, if indeed, it does not entirely revolutionize, on both continents, the present modes of production. I refer to a machine invented and patented by Mr. G. Sanford, designed to operate under a process patented by Mr. J. E. Mallory.

It is not my purpose here to go into any account of this machine and its application, beyond saying that it unites in one operation the various processes by which fibres are extracted manually, from the *endogenous* plants of the tropics. That is to say, it combines the processes of breaking or crushing, scraping, hackling, and washing, in *one* operation; and I feel safe in saying, that by the aid of a machine, not exceeding in cost $100, one expert hand can extract in a single day, (say from the *Agave sisilana* or *hennequin*,) a greater quantity of fibres in better condition, than one hundred men can obtain through the primitive modes now in use. Of its applicability

to *exogenous* plants and cortical fibres, such as hemp and flax, there can be no doubt; but it is as a means of increasing our supply of foliaceous fibres, and utilizing the myriads of tropical plants producing them, but now lost to the world, that it appeals to me with greatest force.

It is in this sense, and with a view of directing American enterprise to new and profitable fields of exertion, that I have here thrown together the various facts relating to vegetable fibres, which I have collected during the ten years since the subject first arrested my attention. I lay but little claim to scientific accuracy, either of classification or of expression; my object being to address myself rather to practical men of general intelligence, who may desire to enter into a new department of profitable industry, than to botanists. At this time particularly, when events have greatly circumscribed the sphere of Northern energy, skill, industry, and capital, and when the world is threatened with a deficient supply of cotton, the question not only of obtaining cotton from other sources than the slave-holding States of America, but also that of increasing our supply of fibrous materials of other kinds, available for similar purposes, and of opening new fields for our enterprise and commerce—at this time, all these have become questions of great, not to say vital, import. If the information which I have before brought together, in connection with the opportune invention to which I have alluded, shall in any way assist in the solution of these pregnant questions, my object, in this publication, will be fully met.

TROPICAL FIBRES.

CHAPTER I.

EXTENT OF CONSUMPTION AND MODES OF EXTRACTION.

In their primitive condition, men clothed themselves in the skins of wild beasts, but when they "multiplied on the face of the earth," they were obliged to supply the deficient resources of the animal, from those of the vegetable kingdom. As they advanced in civilization, the thousand useful applications of vegetable fibres, not alone for clothing, but for cloth for tents, sails, and cordage for ships, and materials for paper, became gradually apparent, affording scope for invention and ingenuity in the arts, and employment for millions of human hands in the departments of production and manufacture. No one need be told how widely and intimately the production, manufacture, distribution, and sale of cotton, enter into the industry and commerce, and even into the social condition and political relations of the world at the present time. The story of its importance is told in the crash of the 300,000 busy looms, and the dizzying whirl of the 30,000,000 of spindles of the British Islands, as well as in the hum of the less numerous but not less active manufactories of our own country.

But cotton by no means supplies, nor does it admit of

supplying, many of the most important requirements of mankind, in the department of vegetable fibres. In none of its applications, can it equal in fineness the delicate cambrics and muslins of Belgium, France, and India, nor can it be used for the coarse but powerful cordage with which the fleets of the world are rigged. The supply of fibres for these purposes has hitherto been chiefly obtained from the flax and hemp plants, but they also fail to meet the demands of the arts in respect of quantity, nor are their fibres equal in other important requisites, such as strength and durability, to those obtained from tropical plants more widely diffused, more economical, and easier of production.

Indeed, the supply of vegetable fibres from all sources, does not meet the present and increasing demands of manufacture, and many of the most important articles of common use, such as paper, are steadily advancing in price, from an absolute and growing deficiency of fibrous materials.

Whence is this deficiency to be supplied? is a question which is more frequently and earnestly repeated with every succeeding year, and to which no satisfactory answer has yet been obtained. It is true, that naturalists, without exception, have always pointed to the tropics, with its numerous and exhaustless varieties of *endogenous* plants, producing foliaceous fibres, such as the agaves, bromelias, the palms, the plantains, etc., as capable, not only of supplying all existing or possible deficiencies, but as capable also, of furnishing new and beautiful, as well as cheap materials, for new and useful manufactures. It is also true, that the production of fibres from tropical plants, has of late years rapidly increased, but not in a ratio equal to the demand for them, owing to the lack of simple, cheap, and efficient machinery for extracting the fibres. Some notion of the extent of the present production and consumption of tropical fibres may be formed from the following tables, which show the amount and value of such as are imported into the United States and Great Britain. It will be remembered, that these amounts are irrespective of those consumed by other countries, or by the people of the tropics themselves.

TABLE I.—Tropical Fibres imported into the United States for the year 1860. (Custom-house valuations.)

KIND.	QUANTITY.	VALUE.
Manilla Hemp,	347,431 cwts.,	$1,631,884*
Sisal Hemp,	5,630 "	25,114
Coir, etc.,	112,585 "	163,039
Gunny Bags,		287,387
" Cloth,		1,795,256
	Total,	$3,902,680

TABLE II.—Tropical Fibres imported into Great Britain for the year 1855. (Estimated real value.)

KIND.	QUANTITY.	VALUE.
Jute (Gunny),	539,297 cwts.,	$2,235,835
Manilla Hemp,	92,755 "	1,443,495
Other Fibres,	8,591 "	51,545
Total,	640,643 "	$4,730,875

Considerable, therefore, as has been the production of tropical fibres up to this time, yet the amount has been insignificant, considering the practically illimitable sources of supply. The deficiency has resulted, as we have already had occasion to remark, from a lack of proper and economical machinery for separating the fibres from the pulpy and woody materials, and the salts and gums with which they are mixed in their natural state. As will be seen when we come to speak of the production of Sisal and Manilla hemp, and of Indian fibres in particular, all the processes for extracting them, at present in use, are to the last degree primitive and inefficient.

The native of Yucatan, in order to obtain the material known as *Sisal hemp*, laboriously splits open each leaf of the *hennequin* plant, and then scrapes and rubs each section

* It will be seen that the valuation of Manilla hemp in the custom-houses of the United States, according to the returns, is only about $4 70 per cwt., while according to the consular returns from Manilla, the original cost there is $8 per cwt. The English official returns are computed on the estimated real value at the port delivered, and give this hemp a valuation of $11 25 per cwt. At this rate, the value of the import of this article into the United States for the year 1860, would be $3,908,848, instead of $1,631,000.

by hand, until the pulpy and coloring matters are removed. Six pounds of fibre per day is the average product of his labor.

The *abaca* of the Philippine Islands, known to commerce as *Manilla hemp*, and of which nearly four millions of dollars' worth are imported into the United States annually, is extracted from the foot-stalks of the plantain, by the slow and primitive process of pounding them with clubs of hard wood, until the porous and gummy matters are expelled, and then passing them frequently through a coarse hackle.

The excellent fibre known as *New Zealand hemp* is prepared from the leaves of a plant of the Lily family, either by beating them with mallets, or by a long and damaging process of drying, maceration, and hackling.

In India, where the natives, for centuries, have been accustomed to extract the fibres by the injurious process of rotting the numerous plants producing them, their masters and instructors, the English, as late as 1855, had no better improvement to suggest to them than that of "*beating the plants with a mallet, and then scraping them, in small handfuls at a time, on a board, with a blunt table-knife, or a long piece of hoop iron, fastened in a straight handle.*"

The processes which have hitherto been adopted, in our own country of boasted mechanical ingenuity, in extracting the fibres of that valuable plant, the *Agave Sisislana*, although in advance of those practiced in other countries for similar purposes, have nevertheless been exceedingly rude and imperfect. The best process, that adopted by Mr. Dennis, of Key West, and published in the Patent Office Report for 1856, consists in crushing the leaves of the plant, placing them in an open-work box to be washed by the flow and ebb of the sea for several days, and then beating them with sticks so as to clean the fibre.

It may be laid down as an invariable rule, that any process for the extraction of vegetable fibres which involves fermentation, or what is known as *rotting* or *retting*, not only endangers and often destroys the strength of the fibres, but also discolors them, so as to render resort to chemical agents, which in turn further weakens them, indispensable in order

to bring them back to the whiteness which they possess naturally, if extracted at the proper time and in the proper manner. On this point we cannot do better than adduce the testimony of Dr. G. T. Schaeffer, whose acquaintance with the subject qualifies him to speak with authority. He says: "With fibres drawn from plants of full activity of growth, in hot climates, the danger from excess of fermentation becomes serious, for a few hours here may do damage which elsewhere it might require many days to occasion. *It must be remarked, too, that many, if not indeed most fibres, require for the attainment of a proper degree of softness and delicacy, to be gathered before the full maturity of the plants to which they belong.* In proportion as this period is anticipated, will the nitrogenous or fermentable matter be present in greater quantity."

Now, it has been ascertained, and the process of Mr. Mallory, referred to in the Introduction to this Memoir, is based on the fact that nearly all, if not all the fibres of the vegetable world are white, while the plants producing them are in their green or growing state, and that they are only discolored by the sap which holds the gummy and coloring matters of the plant in solution when the latter ripens and begins to decay, or by being exposed to the sun's rays. Natural or artificial heat has also the effect, more or less decided, of fixing the coloring matters of plants in their fibres.

It is true, that the use of alkalies in treating fibres, either with or without pressure, in the process of boiling, will take out much of the gummy and coloring matters which they contain, but the heat will fix or set that which is left of a buff color, of greater or less depth, according to the strength of the alkaline bath used. This color is extremely difficult of extraction. If a strong solution of caustic alkali is used for the purpose, with a great degree of heat and pressure, the fibres become greatly expanded, and enough of the coloring matter will be destroyed to render the fibres of a light gray color, which, however, it will require the use of chlorine to get rid of entirely. It is easy to see that such processes for obtaining fibres perfectly white, are not only expensive, but damaging to the fibres themselves.

As already said, the gummy, coloring, and other extraneous matters contained in plants, while in a green or growing state, are soluble in cold water, and may be removed by crushing the plants, and scraping, hackling, and washing them—a compound process which the machine, to which I have referred, performs perfectly in a single operation. In other words, it does automatically, all that experience has shown to be requisite for the proper extraction of vegetable fibres under the tropics, with the advantage of rapidity, whereby the fibres are preserved from the chemical action of the atmosphere.*

* The gum held in solution in all plants while in their green or growing state, when dried into the fibres, renders them harsh, brittle, and more or less unfit for paper and textile purposes. It has been generally believed that the difference in appearance and degree of softness of the various kinds of fibres is owing to their difference in nature; when, in fact, the real difference in softness is generally due to the greater or less amount of gum still remaining in them.

Experience has proved that Manilla hemp makes excellent paper, and the only objection raised by paper makers to the general use of this stock, is its harshness and the difficulty of bleaching it perfectly white; all of which objections are now removed by the use of the Mallory process, with the aid of the Sanford machine. I have recently seen some of the plantain fibre or Manilla hemp extracted under this process and by this machine, which came out almost perfectly white and nearly as soft as silk—proving, beyond a doubt, the correctness of the theory and practice described above.

CHAPTER II.

FIBROUS PLANTS OF AMERICA AND THE EAST INDIES.

Of tropical fibrous plants, America produces indigenously her full share. Those of the pine-apple family, from which the delicate fabric known as *piña* is manufactured, are peculiar to this continent, although they have been introduced on the old continent, where they flourish in such numbers as to constitute an important part of the Flora of the west coast of Africa, and of portions of the East Indies.

The *Bromelia sylvestris*, or wild pine-apple, which produces the silk-grass of the British West Indies, and the *pita* of Mexico and Central America, and which, from its hardy nature, luxuriant growth, and abundant and excellent fibre, seems entitled to rank first among all the fibre-producing plants of the tropical world, (the plantain possibly excepted,) is still only found in its natural *habitat*, although there is no doubt it could be readily propagated in corresponding latitudes, all over the globe. All varieties of the *Musa* or plantain family produce good fibres, and experiment has shown that the peculiar variety which yields the celebrated Manilla grass, (*Musa textilis*,) although indigenous to the East Indies, nevertheless flourishes in tropical America and the Antilles, in as great luxuriance and perfection as in its native soil. The agaves, too, perhaps the largest as they certainly are, taken collectively, the best and most abundantly producing fibre family of the globe, in their economic varieties, are also peculiar to America. The *Agave Americana* has been introduced into the southern part of Europe and into Algeria, and seems to flourish sufficiently well to justify the belief that it may ultimately contribute its share to the fibre crop of those countries. Its brothers, however, the useful *Agave Mexicana* or *maguey*, and the invaluable

Agave Sisilana or *hennequin*, with its sub-varieties, are still peculiar to this continent. It is from the latter that the commodity known as *Sisal hemp* is manufactured. Equally hardy with the wild pine-apple, (*Bromelia sylvestris*,) growing well in every variety of soil, amongst rocks, and in arid wastes where almost every other form of vegetable life disappears, and producing an abundance of excellent fibres, it offers a source of supply of fibrous material, under an easy and economic method of extraction by machinery, only to be limited by the public demand.

Leaving out of view, for the present, the fibre-bearing plants of the palm, lily, and screw-pine families, we cannot characterize the foliaceous fibres of the agaves, bromelias, and plantains, in better, more truthful, or more concise language than that of a man who, before his sudden and melancholy death, had devoted many years of an active life to their study and utilization:—

"Lighter, stronger, more elastic, and more durable than the cortical fibres of hemp or flax, and produced by perennial self-propagation, in stony, sandy, or swampy surfaces, with the easiest and cheapest cultivation, and the speediest and simplest preparation, the relative and positive prices and properties of the foliaceous fibres of the agaves and the plantain, insure their substitution for cortical fibres in the general consumption of mankind."*

* Letter of Dr. Henry Perrine, Consul of the U. S. in Yucatan, dated Campeachy, Nov. 24, 1834, and directed to the Secretary of State of the United States. In making this reference, we should do injustice to the memory of a wise, sagacious, and patriotic man, if we omitted to notice the efforts of Dr. Perrine to introduce the cultivation of the fibrous-leaved plants of the tropics into the United States. During his long residence in Campeachy he became acquainted with the manner of growth of these plants, the modes of cultivating them, and the means of extracting their fibres, and conceived the idea of naturalizing them in the Southern States. Having satisfied himself of the practicability of the enterprise, he petitioned Congress in 1837 to aid in carrying it out on a large scale. His application was successful, and Congress passed a bill, giving to him and his associates, under the name of the "Tropical Plant Company," the pre-emption right to thirty-six sections of land situated in East Florida, below the parallel of 26° north latitude. Small plantations were at once commenced at Cape Florida, and other points in its neighborhood, into which a variety of plants from Central America were intro-

The agaves and bromelias, indigenous to this continent, supply better substitutes for flax and hemp than any of the old-world plants, while the fibre of the banana or plantain can be produced here in as great perfection, and with as much ease, as in the Philippine Islands, or any other part of the East. Yet, as will be seen by reference to foregoing tables, the United States imports annually nearly four millions of dollars' worth of East Indian fibres, against less than one hundred thousand dollars' worth from the tropical regions of America. This is, no doubt, in great part due to the circumstance, that manual labor is cheaper and more abundant in the East than in America, and that consequently fibres can be more cheaply and abundantly produced there, by the slow and laborious hand-processes hitherto in use. But if the great desideratum of simple and efficient machinery for separating foliaceous and other fibres can be met, there is no doubt that our supplies would be obtained nearer home, in greater abundance and at less cost than is now possible.

The celebrated Spanish naturalist, Don Ramon de la Sagra, has given a list of plants, which are suitable for cloth, indigenous to Cuba, with their local names. Leaving out cotton, I subjoin the list, with such information regarding the respective plants as is accessible.

1. *Cañamo de Senegal* (*Hibiscus cannabinus*), also called *cañamazo.* The coarse cloth made from it is used in some parts of the island for

duced. Among these were three or four species of the agave, including the varieties producing the Sisal hemp, the maguey or pulque agave, the cochineal cactus, paper mulberry, date palm, etc. All these succeeded well, and the enterprise promised the happiest results, when the hostilities of the Indians, consequent on the Seminole war, compelled the abandonment of the plantations. Dr. Perrine, however, whose whole soul was devoted to his undertaking, returned, after an interval, and was subsequently killed by the savages. The plants were then neglected, and many of them destroyed; but those that were left have flourished and propagated themselves extensively. Although he did not live to see the fruition of his plans, Dr. Perrine, nevertheless, established the fact that nearly all, if not all, the fibrous plants of Central America and Mexico flourish freely in the Peninsula of Florida, as they no doubt would also flourish, if introduced into the adjacent States to the northward.

clothing the slaves, and is called *coleta*. The fibre is that known in India as *sunnee*, or *sun hemp*. See *Malva*, or *Mallow family*.

2. *Ceiba* (*Bombax ceiba*), or silk-cotton tree, producing a variety of cotton, only useful for stuffing pillows, etc., the fibres not adhering to each other. It is said that this product has been used in making hats.

3. *Chichicastre* (*Urtica baccifera*), a wild shrub, of the Urtica, or Nettle family, also called *chichicate*. See *Urtica*, or *Nettle family*.

4. *Daguilla* (*Lagetta lintearia*, or *Daphne lagetta*, of the natural order *Thymelæ*), is a forest tree, growing to the height of thirty feet, and two feet in thickness. Its inner bark, when cut in thin pieces, after maceration assumes a beautiful net-like appearance, and is used by the natives for aprons, collars, caps, etc. Its fibres are also used for cloth and cordage. The bark of many of the plants of this family is made into ropes and paper. Specimens of the *lace-bark* here described are often seen in the United States, in the form of bands around bunches of Havana cigars.

5. *Flor de calentura* (*Asclepias cursavica*), a wild plant, growing in every kind of soil, more particularly in humid places. It produces brilliant flowers, and discharges, on being cut, a caustic, milky juice, used as a purgative in medicine. Its bark is fibrous, and is made into cordage. The *Jetee*, or *Tongoose* fibre of Madras, is from the stems of *Asclepias tenacissima*, a member of the same natural order, if not the same plant with the above.

6. *Guamá*, or *Gambusino* (*Lonchocarpos tenax*). See *Leguminosæ*.

7. *Guizazo* (*Triumphita Semitriloba et Havanense*). See *Tilia*, or *Lime-tree family*.

8. *Jaguey* (*Ficus indica*). See *Urtica*, or *Nettle family*.

9. *Majágua* (*Hibiscus tiliaceus*). See *Malva*, or *Mallow family*.

10. *Malvaté* (*Corchorus siliquosus*). See *Tiliaceæ*.

11. *Pan de Mono* (*Adansonia digitata;* Natural Order *Sterculiaceæ*), the Baobab tree of Senegal.

12. *Piña* (*Bromelia ananas*). See *Bromelia family*.

13. *Piñuella* (*Bromelia pita*, or *karatas?*) See as above.

14. *Pita* (*Furcræa fœtida?*) See as above.

15. *Pita de Corojo*. See *Palm family*.

16. *Platano*. See *Musa family*.

17. *Quimbombo* (*Hibiscus esculentus*). See *Malva*, or *Mallow family*.

Seeman, in his "Botany of the Isthmus of Panama," page 70, has the following paragraph on the economical fibres of Panama:

"The cordage which the people of the Isthmus use, is solely produced from indigenous plants. The best and whitest rope is made from the fibre of the *corteza*, (*Apeiba Tibourbon*, Nat. Ord. *Tiliaceæ*.)

A brownish looking rope easily affected by dampness, probably because the tree from which it is taken has saline properties, is manufactured from the *Majagua de playa* (*Paritium tiliaceum*, *Hibiscus tiliaceus* L.?) The *Barrigon* (*Pachira barrigon*), and the *Malagueto hembra* (*Xylopia frutescens*), also yields a fibre fit for ropes. The hammocks of Veraguas, consist of the fibres of the *Cabuya* (*Agave sp.*), and those of a palm called *Chonta*. A strong fibre is contained in the leaves of the *Pita de zapateros* (*Bromelia sp.*,) which is prepared like flax, woven into bags or *chacaras* by the different Indian tribes, and extensively used by the shoemakers for sewing. The fibre surrounding the wood of the *Cucua* or *Namagua*, [*Daphne lagetta?*] forms a close texture of regular natural matting, which the natives soak in water, beat, and make into garments, beds, and ropes, or use as sails for their canoes. The mats which the poorer people sleep on, are made from the fibres of the plantain."

The East Indies, although by no means as rich in fibrous *endogens*, as tropical America, is nevertheless rich in *exogenous* plants, producing useful and abundant fibres, of which Great Britain imports annually upwards of $3,000,000 worth, and the United States, upwards of $4,000,000 worth annually. The processes employed in extracting these various fibres are exceedingly primitive and slow, as will appear from the following descriptions, and warrant the belief that with cheap and simple machinery, the present production could be increased ten-fold.

The usual process followed for preparing the fibres of succulent, fleshy plants, consists in cutting them when in full vigor, and burying them in wet sand on the banks of a running stream, or in mud at the edge of a pool or tank, and leaving them to soak, or rot for one, two or three weeks, according to the temperature of the weather. The plants are then taken out, dried in the sun, and beaten with heavy sticks on the dry hard ground, and well rubbed between the hands to separate the chaff and dust. Another method is to take the soaked plants in bundles, and beat out the pulp and impurities on a flat stone, at the edge of a tank or on the shores of a river.

The fibres of the *Marool*, (*Sanseviera Zeylanica*) are obtained by scraping and washing in fresh water, soon after the plant is cut. Those of the *Yercum*, (*Calotropis gigantea*)

are obtained by stripping the plant of its leaves, exposing it to the sun for several days, and then peeling off the bark and picking out the fibres between the thumb and fore-finger.

The Singapore *Free-Press*, in describing these processes very justly observes:—

"The system of cleaning fibres by rotting is not suited to warm climates, inasmuch as putrefaction sets in almost as soon as fermentation; and while one part of a heap of stalks is beginning to ferment, another part is stained from putridity, while the central parts remain fresh and unaltered. *To preserve the color and strength of the fibres it is necessary to separate the pulp, bark, or wood, as soon as possible, and by the least complicated process.* The pulp or juices of plants usually contain mucilage, starch, or gum, which begin to ferment within twenty-four hours after the plant is cut; and if they be left in water during warm weather, fermentation is completed within two or three days. In cold climates it takes as many weeks. The result is that the sap becomes acid, and destroys the strength of the fibre. This is followed by putrefaction, which not only stains the fibre, but makes it brown and brittle.

"If the plant is left exposed to the sun for a day or two after being cut, the sap dries, and the coloring matter stains the fibre, which cannot then be easily separated from the bark, spiral cells, nor woody materials. In some plants this discoloration is green, in others brown or dusky yellow, which cannot be removed by bleaching, as it is a species of natural tanning inherent in the plant. Such fibres always remain stiff, harsh, and woody, with a tendency to snap on a sudden strain. The plantain fibre (Manilla hemp,) is liable to this defect, which can only be obviated by expressing the juice as quickly as possible, and only cutting as much of the plant as can be cleaned in a single day.

"The proper mode of cleaning the fibres of pulpy plants is to crush them between rollers, those of the common sugar mill will answer, and while the fibres are in this condition, seize them at both ends, and twist them in opposite ways to squeeze out the sap. They are then to be well washed in water, untwisted and scraped, in small handfuls at a time, on a board, with a blunt table knife, or a long piece of hoop iron, fastened in a straight handle. When all impurities have been removed, the fibres should be soaked for an hour or two in clean water, and then hung up in the shade to dry. Exposure to the sun, at first, is apt to discolor them. By this process fibres of great strength, of a silky appearance and good color, can readily be procured. The scrapings should be well washed and put aside in the shade to dry as tow for packing or as materials for paper."

"The Indian plants, to the cleaning of which this process is applica-

ble, are those of a fleshy or pulpy nature, such as the aloe, agave, sanseviera, and plantain genera, of which there are many species. The prices in England for Indian fibres thus cleaned, vary from $125 to $350 per ton; while the same fibres, cleaned by the rotting process bring, only from $60 to $90 per ton, and are said to be only suitable for the manufacture of coarse twine, or brown packing paper. The finest plantain fibre (Manilla hemp), when carefully cleaned and dressed, is said to be suited for the imitation of silk in carriage-braid and carpet work. Its average value is $250 per ton, while Russia hemp is selling at $200 per ton.

"Many of the Indian cordage plants are those having bark and woody fibres, and the native process of cleaning is very similar to that of cleaning the plants already mentioned, viz.: by burying them in wet sand or mud, and leaving them to rot. There is this difference, however, that the plants are steeped longer, and are never exposed to the sun to dry. If this were done, the woody portions would get hard and brittle, and adhere to the outer fibre, which, being partially rotten, would break in the cleaning. To obviate this, the rotted plants are taken up in large handfuls and beaten on flat stones, first at one end and then at the other, in the same way that clothes are washed by washerwomen. They are next well rubbed and washed to separate impurities, and spread on the ground to dry. We can hardly wonder, therefore, that most of the cordage made from fibres prepared in this rude, coarse way, should be dark in color, and of little strength and value. As a rule, every day's steeping of a fibre takes from its strength and discolors it. To obviate this, woody plants should be first well beaten with a mallet, and then the bark separated from the stalk, for it is on the inner side of the bark that the fibres for cordage usually occur. When the bark is brought to a pulpy state, it should be well washed in clean water, to remove as much of the sap as possible, for this is the destructive agent, which soon causes putrefaction."

Dr. Royle, whose work on cotton is well known in this country, has published a work on the fibres of India fit for cordage, which, however, I have been unable to consult. The following tables of the comparative strength of these fibres are from experiments made by Dr. Roxburgh in 1808, and Dr. Wright at a later period:

According to Dr. Roxburgh's experiments:

POPULAR NAME.	SCIENTIFIC NAME.	BREAKING WEIGHT.
Bowstring hemp,	Asclepias sp.....	248 lbs.
Caloee hemp,	Urtica *nevia*.....	240 "
Sun hemp,	Crotalaria juncea.....	160 "

POPULAR NAME.	SCIENTIFIC NAME.	BREAKING WEIGHT
Sun hemp,	Crotalaria capsularius.....	164 lbs.
Hemp (Indian),	Cannabis sativa.....	158 "
Doncha,	Aeschynomone cannabinus.....	138 "
.....	Hibiscus strictus.....	128 "
Musat paat,	Hibiscus cannabinus.....	115 "
Bunghi,	Corchorus olitorius.....	113 "
Plantain,	Musa.....	79 "

According to Dr. Wright's experiments:

POPULAR NAME.	SCIENTIFIC NAME.	BREAKING WEIGHT.
Yercum nar,	Calotropis gigantea.....	552 lbs.
Janapun or Sun,	Crotalaria juncea.....	407 "
Catthalay nar,	Agave Americana.....	362 "
Cotton,	Gossypium.....	346 "
Marool,	Sanseviera zeylanica.....	316 "
.....	Hibiscus cannabinus.....	290 "
Coir,	Cocos nucifera.....	224 "

CHAPTER III.

FIBRE-PRODUCING PLANTS.

ALL vegetable fibres used for textile purposes, resolve themselves into three great classes, viz.: Foliaceous fibres, Cortical fibres, and Capsular fibres.

1. *Foliaceous fibres.* These are obtained from *Endogenous* or *Monoctyledonous* plants, or inside-growers, which are best known to us in their herbaceous forms, such as the grasses, including the cereals, sugar-cane, and the common cane, as also the lily, the cat-briar, and all plants in which the leaves have parallel veins. Under and near the tropics, the *endogens* are represented by the yuccas, the agaves, the plantain, and the great family of palms. These plants do not form a regular bark, show no signs of annual growth, and do not increase by continual additions to the outside of the stem, as is the case with the trees common to our climate. Their fibres are imbedded in the cellular tissues and pulpy matter of their stems and leaves, and may in most, if not all cases, be extracted by a purely mechanical process. The fibres known as Manilla hemp, Sisal hemp, silk-grass, etc., are obtained from plants of this class. It is only in tropical and sub-tropical regions that *endogenous* plants attain any great development, take arborescent forms, or yield fibres suitable for textile purposes. To an inhabitant of the Northern temperate zone, an *endogenous* plant of which the green leaves yield valuable fibres, is a curiosity only to be seen in conservatories or botanical gardens.

2. *Cortical fibres.* These are obtained from what are botanically known as *Exogenous* or *Dicotyledonous* plants, or outside-growers, and are contained in their bark or *bast.* They are often of great length, but little hardened, and with the

exception of cotton, are the most valuable produced in temperate climates. Some of the plants of this class attain great size. A familiar example is the linden (*bass* or *bast-wood*) of Europe and our own country, and the wild-fig or banyan tree of the tropics. A greater number, however, are herbaceous, such as most of the *Mallows*, (in which is embraced the cotton plant,) a large part of the *Urtica* or nettle family, (embracing the familiar hemp,) the *Linacea* or flax family, and some varieties of the *Leguminosæ* or pea and bean tribe, such as the *Crotalaria juncea*, which supplies the *Sun* or Bengal hemp. The stems of these plants consist of a woody core, surrounded by a sheath of fibrous texture, and the two are connected by a peculiar vegetable glue, which unites them in a solid stem. In the preparation of flax, hemp, China-grass, etc., the object is to remove this matter, and thus separate the useless stem from the valuable external sheath of fibres.

3. *Capsular fibres.* These, as the name indicates, are obtained from pods or capsules. Cotton, a familiar type of this class, is found in the capsules of the Gossypium, enveloping the seeds, and in nearly all cases closely adhering to them.

With these general observations, we proceed to notice the plants of the two great natural divisions, the *exogens* and *endogens*, which are most valuable for their fibres, as nearly as possible in the order of their importance—giving the leading place to the *endogens* as essentially tropical, and as offering the widest opportunity for an increased production of fibres through the aid of proper machinery.

CHAPTER IV.

ENDOGENOUS PLANTS.

SIX orders of the *endogens* yield fibres which are commercially valuable, viz.: 1st, the Agave or Amaryllis family; 2d, the Bromelia or pineapple family; 3d, the Musa or plantain family; 4th, the Yucca or lily family; 5th, the Palm family; and 6th, the Pandanceæ or screw-pine family.

I.—AGAVE, OR AMARYLLIS FAMILY.

Many of the plants belonging to this family produce excellent fibres, in great abundance, and are indigenous in all parts of tropical and inter-tropical America, over a broad belt of at least 33° on each side of the equator, from Virginia on the north, to Paraguay on the south. They are easily cultivated, hardy, and flourish equally in the richest and in the most sterile soils. Indeed, in thousands of places, where rocky, indurated, and sandy and arid soils prohibit every other kind of vegetation, the agaves find root and a vigorous growth. Several varieties are indigenous in the United States, such as the *Agave Virginica*, which is found in the worst soils from the Potomac to the Mississippi, and the *A. vivipera*, which is found in Florida, and perhaps in some of the other States fronting on the Gulf of Mexico. It is, however, under the tropics proper, throughout Mexico, Central America, the northern States of South America, and in the West Indies, that the agaves are most abundant, and may be multiplied to any extent necessary to meet the demands of the world for the kind of fibres which they produce.

Several varieties of the Mexican and Central American agaves were introduced into Florida a number of years ago, by Dr. Henry Perrine, and were found to flourish luxuriantly; but their cultivation does not seem to have been followed up, probably because of the lack of cheap and efficient machinery for separating the fibre.

The fibres extracted from the agaves differ widely in fineness and consequent value, although all are available for cloth, cordage, and paper. The fibre, it is said, also varies considerably with the age of the plant, being most pliable and easily worked if taken when the plant is young.

Superficial writers and travellers have caused great confusion and uncertainty in respect of the agaves, by confounding the different species, and their contradictions have much embarrassed practical men in their calculations and efforts for utilizing them. This uncertainty and confusion have been greatly increased by the different and difficult names (generally Indian) by which the agaves are distinguished in the various parts of the continent. In Mexico the different varieties are called *Maguey*, *Maguey de Pulque*, *Metl*, *Cabulla*, *Hennequin*, *Sosquil*, etc.; in Yucatan and Central America, *Hennequin*, *Cabulla*, *Pita*, *Yashqui*, *Sacqui*, etc.; in Cuba, *Maya*, *Hennequin*, *Pita*, *Piñon*, etc.; in Venezuela and New Granada, *Cocuy*, *Cocuiza*, etc.; and in Brazil, *Grawatha*, etc. Great confusion also exists in the names of the fibres extracted from the Agaves and those taken from the Bromelias, or plants of the Pine Apple family, which are often confounded, even in the countries where they are produced. The following descriptions, however, will serve to correct, in part at least, some of the mistakes in these respects.

Clavijero, in his History of Mexico, has epitomized the uses of the various kinds of agaves of that country, in the following language:

"Some species furnish protecting inclosures, and afford impassable hedges to other objects of cultivation. From the juice of others are extracted honey, sugar, vinegar, *pulque*, and ardent spirits. From the trunk and the thickest part of the leaves, roasted in the earth, an agreeable food is obtained. The flowering stalks serve as beams, and the leaves as roofs

for houses. The thorns answer for lancets, awls, needles, arrow heads, and other cutting and penetrating instruments. But the fibrous substance of the leaves is the most important gift of the agaves to Mexico. According to the species, the fibre varies in quality from the coarsest hemp to the finest flax, and may be employed as a superior substitute for both. From it the ancient Mexicans fabricated their thread and cordage, mats and bagging, shoes and clothing, and webs equivalent to cambric and canvas; the hammocks in which they are born, repose, and die; the paper on which they painted their histories, and with which they adored and adorned their gods. The value of the agaves is enhanced by their indifference to soil, climate, and season; by the simplicity of their cultivation, and by the facility of extracting and preparing their products. It is not, therefore, surprising that the ancient Mexicans used some part or preparation of these plants in their civil, military, and religious ceremonies, at marriages and deaths, nor that they perpetuated an allusion to their properties in the name of their capitol."

1. *Agave Sisilana*, so called from the city of Sisal, in Yucatan, whence the fibre, extracted slowly by hand, has found its way to market under the name of *Sisal hemp*, or *grass hemp*.

This plant, called *Sosquil* in Mexico, and *Cabulla* in Central America, is indigenous in every part of tropical America, and may be cultivated with the greatest ease, to any desirable extent, as well on the very stony surfaces of the interior, as on the very sandy soils of the coast. There are two varieties, distinguished in Yucatan as the *Yashqui hennequin*, which produced the best quality of Sisal hemp, and the *Sacqui hennequin*, which gives the greatest quantity. In Central America the fibre of both these varieties is called *Cabulla*, and is used for cordage; while the fibre of the *Bromelia sylvestris*, distinguished as *pita*, is fine, and used for thread and cloth. Both are admirably adapted for the manufacture of paper of toughness and beauty.

Plate I, represents the *Yashqui* variety of the *Agave Sisil-*

ana, after its first crop of lower leaves has been cut off for manufacture. It has thick, fleshy leaves, without the spines, or serrated edges which characterize most of the *Bromelias*. They vary in length from five to twelve feet, and in width from three to five inches, the fibres running the whole length.

The wood cut, *Fig.* 1 represents a leaf cut green and perfect from the stalk.

Fig. 2 represents the same leaf, with its fibres exposed from the point *a a*, by means of a triangular wooden scraper, *Fig.* 3, which is used by the Indians in removing the pulpy part of the leaf.

Fig. 4 is a notched wooden instrument, used in splitting the leaf into strips, five or six in number, each of which is afterward worked by the triangular scraper, which is used after the manner of a currier's shaving knife.

By this primitive process all the Sisal hemp brought to market, as well as the infinitely larger quantity used by the natives themselves, is slowly and laboriously extracted. The workmen obtain only from five to six pounds per day.

In the communication made to the government by Dr. H. Perrine, in 1834, and already referred to, that officer speaks of the *Yashqui hennequin* as follows:

"I beg the department to reflect on the fact that the very strong, light, durable fibres of this plant, extracted from the fresh leaves by simple scraping, are immediately converted into cheap cloth for bagging, etc., without spinning, twisting, or any intermediate preparation or fabrication whatever. By the quadruple properties united in the single untwisted, foliaceous fibres of *hennequin*, they become a superior substitute for the compound, twisted, cortical fibres of hemp, in the manufacture of many coarse articles of extensive consumption, hitherto woven of spun thread, and will furnish cheaper equivalents for baling and envelopes in general, than any other kind of extracted fibres, or any other material that can be woven, netted, matted, or plaited, except dried, undressed fibrous leaves. Indeed, they are here used instead of hair for sieves; instead of withes for baskets; instead of leather and wood for valises and trunks, and even as

FIG 4.

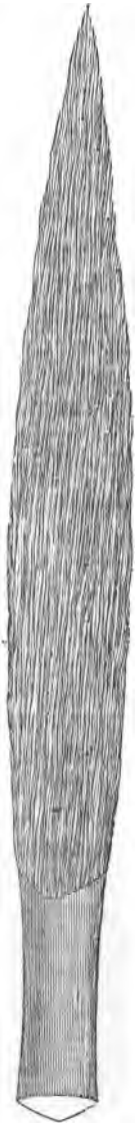


FIG. 2.

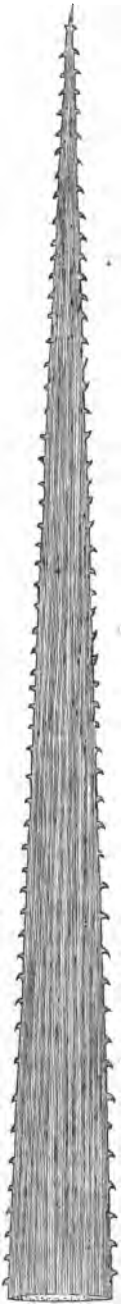


FIG. 5.

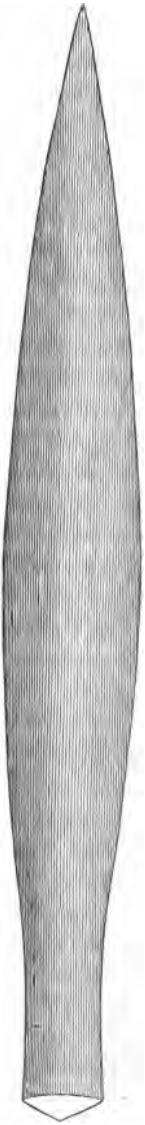


FIG. 1.

FIG. 3.

curious substitutes for glass and clay in the shape of bottles, bowls, cups, and saucers. Hence I believe that if introduced into the United States, the fibres of the *hennequin* would speedily be converted into a thousand forms of ornament and utility, all combining cheapness, strength, lightness, and durability."

The method of cultivating the *Agave Sisilana*, and of preparing its fibres, as practiced in Yucatan, are described as follows, in the Illustrated Report of the Great Exhibition in New York, in 1853:—

"The young plants are placed about twelve feet apart, a stony or sandy location being preferred. During the first two years some labor is required to destroy the weeds between them. The shoots when transplanted should be about three feet high, and are ready to yield two years afterwards. The third year the cutting of the lower leaves is commenced, and every four months the operation is repeated. Each robust plant is capable of yielding from 25 to 100 leaves annually, and will last from five to ten years. Seventy-five ordinary leaves are estimated to yield seven and a half pounds of fibre; the most productive leaves being from the fourth cutting. At intervals of two years, shoots are thrown out from the roots, from five to ten in number, in a state to be transplanted. These are removed with a single exception, to form new plantations, and the parent plant is also cut down, when the shoot left has grown sufficiently to supply its place. If the parent plant be suffered to grow, it eventually shoots up into gigantic flower stalks, from 20 to 30 feet in height, with its superior extremity covered with innumerable little plants, called *hennequenitos*, little *hennequins*. The hardiness of the young shoots may be inferred from the fact that when cut from the parent stem, they are exposed to the sun for fifteen or twenty days, to '*cicaterize their wounds*' as a necessary preparation for replanting. 'The simplicity of their cultivation,' says a writer on this subject in 1838, 'may be conceived from the statement that there is not a hoe, nor a spade, nor a harrow, nor a plough, employed in the agriculture of all Yucatan.'

"The instruments and methods used by the natives of

Yucatan for extracting the fibres from the leaves, are of the rudest description. A triangular strip of hard wood, with sharp edges from eight to twelve inches long, and from one to three inches thick, is with them an equivalent to the shaving-knife of the curriers, by which they scrape away from each side of the leaf, on a board resting against the breast, the cuticle or pulpy substance that covers the fibres. Another mode of accomplishing the same object is, by pressing the sharp, semi-lunar extremity of a long flat stick against any fixed surface upon a narrow longitudinal strip of the leaf, which is then drawn through by the unemployed hand. The length, weight, strength, and other qualities of the fibres, as well as the labor of separating them, vary with the magnitude, age, and position of the leaves. The fibres, after being freed from the investing pulpy matter, are washed and dried in the sun, which thus completes the labor of preparation, and the Sisal hemp is then ready for market.

"One great difficulty in Yucatan, has been the want of a proper machine for suitably cleaning out the fibres of the Agave from their enveloping tissues; the rude process followed by the natives being too slow and expensive. An Indian with his sharp stick only, and indolent habits, will generally clean from four to eight lbs. per diem. A few years since a machine was invented in Massachusetts, for cleaning the fibres, and sent out to Merida, by a Boston firm, having large commercial dealing with that city. The machine is understood to have worked well, but the vegetable acid generated by the fermentation of the expressed juice of the leaves, corroded the metallic parts of the machine it was brought in contact with, to such an extent as to render them useless. The plan had consequently to be abandoned. Within the past year (1852), a chemical process has been discovered, which dissolves the green, fleshy part of the leaves, which the fibres remain intact, and after washing are ready for use."

Dr. Perrine, an enthusiast in the matter of tropical fibre-producing plants, succeeded in 1838, in introducing into Florida, the *Agave Sisilana*, as also the Pulque plant, or

Agave Mexicana, and the Century-plant or *Agave Americana*. According to a statement from Mr. W. C. Dennis, of Key West, published in the Report of the Patent Office for 1855, both the *Agave Americana* and *Mexicana* thus introduced, not only survived the change of climate, but increased rapidly, until they were destroyed by an incursion of the Seminole Indians, in 1846. Of the three varieties, Mr. Dennis, after expressing his belief that the plant producing the Sisal hemp, is of most importance in an economical point of view, proceeds:

"This gigantic plant delights in dried, rocky land containing an abundance of lime, and there are thousands of acres of land in this region, worthless for every other agricultural purposes, on which a ton of cleaned Sisal hemp might be produced yearly, after the plant has reached an age to allow of cutting off its lower leaves, which would be in from three to five years according to circumstances. Neither the growth of the plant nor the amount of its product here, is any longer an experiment. Nor is there any longer a doubt as regards the value of the fibre, a number of tons of it having been collected and sent to market, where it readily brought within half a cent per pound, as much as the best Manilla hemp, that is about $250 per ton. A thousand plants should be set to the acre, and from the constant shoots which spring up, it will be seen that the same land will not require replanting. After the plant is of sufficient growth, the lower leaves are cut off, at proper times, leaving enough on top to keep it healthy. These leaves are composed of a soft watery pulp, and are from two to six feet long, from four to six inches wide in the middle, and frequently three inches thick at the butt; having the general shape of the head of a lance. They contain a gum which is the chief cause of their being rather troublesome in separating the fibres from the pulp. Neither the epidermis nor the pulp is more than a powder, after becoming dry, if the gum be entirely crushed or washed out. This is a most important fact, in relation to the manner to be adopted to cleanse the fibres from the pulp. As these are continuous and parallel, and imbedded in the pulp, I

feel certain that a system of passing the leaves through a series of heavy iron rollers, firmly set, something like those of a sugar mill, and throwing water on the crushed leaves, in jets or otherwise, in sufficient quantities to wash out the gum, (which is perfectly soluble in water) will thoroughly clean the fibres without loss, so that when they become dry, and have been beaten to get out the dust, they will be fit for market. *At any rate, the right plan for separating the fibres has not yet been discovered, although there has been enough done in it to show that they can be got out at a profit.* Here, the people either preserve the primitive process which is practiced in Yucatan, of beating and scraping the leaves, or, after crushing them between a pair of rollers, steeping them in an alkaline solution for a few days, and then hackling them. But both scraping and combing destroys too many of the fibres by breaking them, which would not be done by a system of rolling and washing out the gum. In Yucatan, they sometimes ferment the beaten leaves in water or mud; but this stains and weakens the fibres so as to reduce their value, I believe, more than half. Even steeping the crushed leaves in an alkaline pickle, although it may not much weaken the fibres, as the juice of the leaves is acid, nevertheless destroys the silky gloss which they possess when got out of the fresh leaves, by the aid of pure water alone, besides increasing the cost of extraction. I have some fifty acres of the plant under cultivation, and am increasing the quantity as I have opportunity."

In a subsequent communication to the Patent Office, published in its Report for 1856, Mr. Dennis gives some additional information concerning the cultivation of the *Agave Sisilana* in Florida, as follows:

"Mr. Hermonds, of Indian River (Florida), informs me that the Sisal hemp grows well there, and has continued to thrive well for four years. He thinks that my estimate of a ton of fibre per acre is too low. The experiments which I have made during the past year, in getting out a number of tons of this fibre, prove that all the vesicles of the leaves are ruptured by crushing or rolling, and that the pulp or gum can easily be washed out by either salt water or

fresh. The plan which I have found most successful, was to wet the leaves, being careful to rupture all the vessels, then confine these crushed leaves in an open-work wooden frame or box, which I placed in such a manner that the tide forced the sea-water through them both at the ebb and flow. In this manner the gum and pulp were so far washed out, in from three to six days (according to the temperature of the air and water), that by beating the fibres a little, they were fit for market.

"Mr. Hermonds mentions, as a tested fact, that steeping the crushed leaves in boiling water, even for a few minutes, at once dissolved the gum and cleaned the fibre. This renders it almost certain that where a steam-engine is used to propel rollers and crush the leaves, the waste steam can be rendered effective to clean the hemp, by blowing it off between the rollers, aided by a little water, in a jet, while the leaves are passing through."—*A mistake.* *See Ante, p.* 13.

The amount of *Sisal hemp* imported into the United States in 1854, was 925,900 lbs., valued at the Custom-house, at $64,516, but having a real value of upwards of $100,000.

There is a species of *Agave* which is akin to the *Sisilana*, having also *thick, fleshy, non-spinated* leaves, known as *Furcræa gigantea.* See *Plate* II. A variety of it, the *Furcræa fœtida*, grows in Cuba, and is said to yield valuable foliaceous fibres. Its leaves, however, seldom exceed three feet in length.

2. *Agave Mexicana, or Maguey*, sometimes called *Pulque Agave*, is one of the most remarkable, as well as one of the most useful of the *Agaves.* From its developing stalk it yields a sweet liquor, called *pulque*, which, when fermented, gives an intoxicating drink, used by the Mexicans in place of beer, wine, and cider. Its leaves also furnish a good fibre, fit for various manufactures, particularly for paper.

Plate III. shows the plant when the developing central stalk is cut away and scooped out, forming a natural reservoir, into which the sap or juice distils. It will be seen that the leaf is thick and fleshy, broader than that of the *Agave Sisilana*, and not so long, and moreover, having saw or scolloped sharp edges.

The *Maguey* is chiefly cultivated in Mexico for its juice.

The plants are set in rows, about five feet apart. When the *hampe*, or central stem, which often attains the height of forty or fifty feet, is on the point of efflorescence, it is cut out, and a hollow scooped for receiving the sap. This keeps running for two or three months, the reservoir being emptied three or four times a day. The yield from a vigorous plant is about four hundred cubic English inches per day, or, for the period of yield, from forty to seventy thousand cubic inches, or from two to three hundred gallons! This enormous product is all the more remarkable from the fact that the *Maguey* plantations are generally in arid grounds, and frequently on ledges of rocks scarcely covered with vegetable earth. The plant has firm and vigorous leaves, and is neither affected by drought, wet, hail, nor by the excessive cold which prevails in the higher Cordilleras of Mexico. It perishes after efflorescence, but an infinity of shoots then spring from the decaying roots. No known plant multiplies with greater facility.

The fibre of the *Maguey* is coarser than that of the *A. Sisilana*, but nevertheless of great utility, and extensively used. The ancient Mexicans painted their hieroglyphical records and ritual calendars on paper made from the leaves of this plant, macerated in water, and the fibres deposited in layers like those of the Egyptian cyperus (papyrus) and the mulberry of the South Sea islands. And in modern times the fibres are used for a corresponding purpose.

Indeed, the paper made from the *Maguey* is so much esteemed for its toughness and durability, over that made in the United States and Europe, that in 1830 a law was enacted by the Mexican Congress, requiring that no other kind of paper should be used in recording the laws, or in the execution of legal documents.

3. *Agave Americana.*—This plant, which has been naturalized in the south of Europe and Algeria, is often confounded with the *Maguey* or *Agave Sisilana*. Its flowering or central stem, when the plant is vigorous, rises to the height of 40 feet or upwards, and throws out branches on every side, like those of a candelabrum, so as to form a kind of pyramid, each branch supporting a cluster of greenish red flowers. These

give place to bulbous seeds, which when planted spring up rapidly and luxuriantly. The original plant however dies. The time of flowering varies with localities and climate. An erroneous notion is that it flowers only once in a hundred years. Hence the popular name of *Century Plant*. *Plate* IV. represents the plant in full flower. The fibres from its leaves closely resembles those from the *Maguey*. It is a hardy plant, and often covers rocky, barren eminences, where every other kind of vegetation fails to take root.*

There are eight paper mills in Mexico, which manufacture from cotton and the *pita*. Their product, however, is not equal to the consumption. Mr. Brantz Mayer, in his work (*Mexico as it Was and as it Is*, p. 313), observes: "The best coarse wrapping or envelope paper I have ever seen, is made in Mexico, from the leaves of the *Agave Americana*. *It has almost the toughness and tenacity of iron.*"

4. *Agave vivipara* and *Agave Virginica*, are both interesting as being indigenous in the United States from Virginia southward to Florida. The *vivipara* never grows to a large size, and as it produces no suckers from the root, it can only be propagated from its bulbous seeds, after flowering. William Bartram, the celebrated traveler-naturalist, saw this variety, in his botanical tour through Forida in 1731, near the Mosquito river. His words are:

"I continued along the beach for a quarter of mile, and came up to a forest of the *Agave vivipara*. I term it a forest, because the scapes or flower-stems rose erect near 30 feet high, their tops branching in the form of a pyramidal tree, and those plants growing near each other, occupied a space of ground of several acres. When their seeds are ripe, they vegetate and grow on the branches until the stem dies, when

* Mr. Stephens, in his "Incidents of Travel in Central America," describing his journey from Chiquimula to Copan in Honduras, speaks of ascending a high mountain:

"The ascent was toilsome, but the top was open, and so covered with that beautiful plant (*Agave Americana*,) that we called it the Mountain of Aloes. Some were just peeping out of the ground, others were 20 or 30 feet high, and some gigantic stalks were dead; flowers which would have kindled rapture in the breast of beauty had bloomed and died on the desolate mountain, unseen except by the passing Indian."—Vol. i., p. 90.

the young plants fall to the ground, take root, and fix themselves in the sand."

Plate V, represents the *Agave Virginica*, which resembles the *vivipara* so closely as to be distinguished with difficulty. Its leaves are numerous, of paler color, and its stems are not so high, nor do they branch in the same manner.

Both varieties, it is fair to presume, produce useful fibres; but I am not aware that fibres have been extracted except from the *Agave vivipara*, specimens of which, of admirable quality, were shown in the great Exhibition of 1851.

II.—Bromelia or Pine-Apple Family.

The plants of this family are all indigenous to the continent and islands of America, and many of them yield fibres of excellent quality. One variety, that producing the delicious fruit known as the pine-apple, (*Ananassa sativa*) has been introduced into the East Indies, where its fibres have been extensively used in the manufacture of the delicate fabric called *piña* (pronounced *pinya*), as also for cordage, etc. The piña fabric, more delicate in texture than any other known of the vegetable kingdom, is woven from the untwisted fibres of the pine-apple leaf, after they have been reduced to the greatest fineness. In order to produce a continuous thread, the selected fibres are glued together at their ends, forming an unbroken line, by which means the even character of the fabric is produced. In the great exhibition of 1851, in London, beautiful pine-apple thread was exhibited from Java, Celebes, Singapore, Madras, and other parts of India. The fibres of the *Bromelia sylvestris*, known in Mexico as *istle* or *ixtle*, and in Central America as *pita* or *piñuella*, however, are probably more valuable, in every sense, than those of anyother tropical plant, and it would seem may be produced more readily than those of *Agave Sisilana*.

1. *Bromelia sylvestris*, or wild pineapple, the *istle* of Mexico, but known as *pita* and *piñuella* in Central America and Panama, and in the West Indies as *Bromelia pinguin* or *penguin*, can hardly be said to rank second to the *henne-*

quins in economic importance. It is widely diffused throughout the tropics, growing everywhere, in all varieties of soil. It is extensively used for hedges, for which its long, straight and spiny leaves admirably adapt it, and may be cultivated with a minimum of labor and cost, and in unlimited quantities. *Plate* VI. represents this plant, with its flowering stem and fruit yet undeveloped. It is closely allied to the pine-apple, but the fruit is different, the ovaries failing to combine in one mass, as in the case of the pine-apple, the formation of which they well illustrate.

The leaves are five to eight feet long, from one and a half to three inches wide, thin, and lined with a fine, tough fibre, the *pita*, equal in strength and beauty, and in other respects better than that of the *hennequin*. It is altogether a superior substitute for flax.

This plant is self-propagating, and left to itself in an open field, will soon cover the ground. In Central America, but particularly in Nicaragua, it is so abundant in the forests as to be a serious obstruction to the passage of man or beast. *Fig.* 5, page 29, represents a leaf of this plant, showing the difference between it and that of the *hennequin*. It is largely cultivated in the district of Coatzacoalcos in Mexico, where, according to a report made to the Mexican government, there were in 1830, not less than 1,221 *istales* or *istle* patches. In the same year, there reached the port of Vera Cruz, by the pass of San Juan alone, 943 bales of fibre, of 200 lbs. each, equal to 188,600 lbs.

Major Barnard, U. S. A., in his report on the Isthmus of Tehuantepec, speaks as follows of the *Istle:* "Among the spontaneous products of the Isthmus is the *Bromelia pita*, or *ixtle*, which differs in some respects from the *Agave Americana* of Europe, the *pulque maguey* of Mexico, and the *Agave Sisilana* of Yucatan. Of this prolific plant there are numerous varieties, all yielding fibres which vary in quality from the coarsest hemp to the finest flax. It is indifferent to soil, climate, and season, and the simplicity of its cultivation, and the facility of extracting and preparing its products, renders it of universal use. From it is fabricated thread and cordage, mats, bagging, and clothing, and

the hammocks in which the natives are born, repose, and die. The fibres of the *pita* are sometimes employed in the manufacture of paper; its juice is used as caustic for wounds, and its thorns serve the Indians for needles and pins. The place generally selected for its cultivation, is a thick forest, from which the small undergrowth is removed by cutting and burning. The roots of the old plants are then set out at a distance of from five to six feet apart, and at the end of a year the leaves are cut and 'rasped.' When the ixtle is young its fibres are fine and white, but as it increases in age, they become longer and coarser. In this manner it is easy to select the quality of fibre required. In a wild state its thorns are very numerous, but by cultivation they are diminished both in size and number, and in many instances there are none at all. *Even with the imperfect instruments used in cleaning the leaves, four and five pounds of fibre per day is only a fair average for the labor of a man."—Isthmus of Tehuantepec*, p. 185.

In the year 1857 (Jan. 14), Chief Justice Temple, of Belize, or British Honduras, read a paper before the Royal Society of Arts of London, on the resources of that country, which, as is well known, forms part of Central America. Amongst other objects of interest, he exhibited a quantity of the fibre of the plant under notice, as well of the *Agave Sisilana*. Of the former, or *Bromelia sylvestris*, he said: "The plant called *Bromelia pita*, *istle* by the Mexicans, and *silk-grass* by the Creoles of British Honduras, grows spontaneously in the greatest abundance. The leaves are of a soft, dark green, from five to thirteen feet long, and from a inch and a half to four inches wide. Along the edge of the leaf, about six inches apart, are short, sharp, curved thorns. When the plant is cultivated, these gradually disappear. The fibre which the leaf contains is unquestionably of a very superior description, and I have no doubt could be used in every species of textile fabric. I have been informed by leading manufacturers that this fibre is equal to the best China grass, superior to the New Zealand flax, and capable of being manufactured into the finest fabrics."—*Journal of the Royal Society of Arts, Vol. V., p.* 125.

In the discussion which took place among the leading members of the Society, on the paper of Judge Temple, Mr. P. L. Simmonds, editor of the *Mark Lane Express*, said:

"I have, to-day, seen some of the indigenous specimens of the *penguin* or *bromelia* from Honduras, which have been operated upon by a new patented process of Messrs. Pye Bros. of Ipswich, and am astonished at the remarkable improvement and high commercial value which have been given to the article. *The main difficulty that has stood in the way of utilizing many of these fibres, and making them cheap, and of universal use, has been the want of cheap and efficient machinery for preparing them, and getting rid of the gummy and other matters which surround them, without injury to the fibres. Such machinery is a desideratum of the age.*"

Mr. Pye remarked that, "On the authority of practical men, he could confidently assert that the fibre of the *pita bromelia*, from its strength and quality, might be rendered fit, by the hackling process, for the finest fabrics."

Mr. J. B. Sharp said that "He could confirm all that had been said by those who preceded him. He had that morning submitted some of the fibres to a close microscopical examination, and had ascertained that each fibre contained from 5 to 12 or more fine filaments, held together by gummy matter, capable of being dissolved by proper processes. Some of the specimens before them had been passed over the comb or hackles of a flax mill, and had been pronounced by the most experienced flax spinners of the country (England) to be greatly superior to Russian flax, and approaching the best description of Belgian, in capability of application to the finest textile fabrics. * * A material point to be considered was the machinery to be employed in obtaining these fabrics. On this head he would observe that the plantain, one of the most luxuriant plants in growth, could be easily prepared with one machine, while the silk-grass or *penguin*, etc., required a machine essentially different in construction. * * The leaf of the silk-grass consisted of two different structures; the upper side being of a soft or pulpy character, easy of removal; and the under side of a harder or more ligneous character, and

more difficult to separate—these two external bodies holding the fibre between them. The preparation of the fibre, however, was a question of mere mechanical arrangement. * * He had no hesitation in saying that the three British colonies of Jamaica, Honduras and Guiana were capable of furnishing fibres from the plants in question to the value of $15,000,000 per annum."

There is another variety of this plant, the *B. karatis*, which is hardly to be distinguished from the *B. penguin* or *sylvestris*. It is found chiefly in the dark woods, and has been supposed by some to be the true *B. sylvestris*, changed only by the conditions of its growth. It is probably equally valuable for its fibres. See *Plate* VII.

III.—*Bromelia ananas*, or edible pine-apple, which also affords fine foliaceous fibres of practical utility, has leaves about three feet long by an inch and a half to two inches wide, strongly edged with spines. These may all be worked when the fruit is cut, the plant being perpetuated by shoots from its base. Left to itself, these shoots will gradually cover the entire ground. The shortness of its leaves, however, render this plant inferior in value to its wild brother, the *Bromelia sylvestris* or *penguin*. The plant, which is a native of America, has been introduced in the East Indies, where its fibre is extensively used in manufacturing the delicate fabric known to commerce as *piña*. See *Plate* VIII.

III.—Musa or Banana Family.

The various members of this family rank only second to the *Agaves* and *Bromelias* in the quantity and value of their fibres. Several varieties are cultivated for food, yielding a delicious and nourishing fruit, and in such abundance that Humboldt estimates the product of a single acre as equal to the average product of 133 acres of wheat, and 44 acres of potatoes. An interesting, and for the purposes which we have in view, a most important fact, is that the tree or plant, whether plantain or banana, is almost universally cut down when the fruit is gathered. With proper machinery for extracting the fibre, the many millions of plants thus left to

rot, could be converted into articles of first utility for mankind, such as cordage, cloth, paper, etc.*

Manilla Hemp.—The fibre known to commerce as *Manilla Hemp* is extracted from a variety of the Banana, the *musa textilis.* It is a round, silky-looking fibre, nearly white. It is admirably adapted for cordage, and from the finer fibres, obtained from the petioles of the leaves, are made many of the delicate and celebrated muslins of India.

The stems of all the plants of this order or family are made up of the united petioles of the leaves. They contain such a remarkable abundance of spiral vessels that they can be pulled out by handfuls, and are sold for tinder. Each spiral vessel contains six or seven fibres, which when separated constitute the *Manilla Hemp.*

The value of Manilla Hemp, in the English market, is about $25 per ton more than the best Russian hemp. †

* In the official report of the great Exhibition in London (1851) it is stated that the plantain produces "three kinds of fibre resembling hemp, hard silk, and cotton, capable of being worked into cordage, fustians, lawns, gauze, blonde-lace, and candle-wicks."

† In the consular returns for 1854, published by order of the United States Government, (vol. iv., p. 200), under the head of "Manilla," it is said of the Manilla shipping.

"The standing rigging is of European rope, and the running rigging of rope made from the fibres of the plantain tree, called in the United States *Manilla hemp*, and in this market *Abaca*; or from *Maguey*, a fibre identical I believe with that known in the United States as *Sisal hemp.* Manilla cordage is usually sold at an advance of $4 per *picul* on the cost of hemp, or from 7 to 9 cents per lb. The *Maguey* rope is much cheaper, but inferior, owing to the hemp being imperfectly cleaned. * * The hemp which is the principal product of these islands (Philippines), and is grown nowhere else, with advantage, is in such favor in the United States that to this date the demand has in no year being fully supplied. To this article is due the increased commerce with the United States. * * The plantain tree from which the hemp is obtained, is cultivated with the greatest facility, *but the operation of separating and cleaning the fibres is very laborious.* A machine has recently been invented by an American engineer in Manilla, which it is to be hoped may be useful in saving labor and increasing the production.

"The export of Manilla hemp, to the United States and Great Britain for 1852 was 44,018,000 lbs., or in value $5,350,000. To show the rapidity with the demand for this product has increased, it is only necessary to mention that the total export of the Philippine islands for 1839–40 was only 5,870,000 lbs."

Plate IX. exhibits the appearance and mode of growth of the *Musa rosacea* or red banana, and will serve to illustrate the entire class. The lamina, composing the stalk, are from 10 to 14 feet long, by from 4 to 6 inches broad, and are used for many purposes, such as matting and wrapping, in their natural state, without any other preparation than pressing and drying.

Among the articles sent from British Guiana to the Crystal Palace exhibition in New York, in 1853, were a large variety of the products of the plantain and banana, consisting as well of their prepared fruit, as of the fibres, and cloth, cordage, and paper made from it. I extract from a report on the exhibition, published in Demerara, a number of interesting paragraphs on these plants and their products, all of which concede that proper machinery to extract the fibre, is alone requisite, in order to make it an article of prime commercial and industrial value.

"Many indigenous (and this is true of all tropical American countries, as well as of Guiana,) contain fibre which might be turned to profitable account, as a substitute for hemp. Cordage of every thickness, from the finest line to the stoutest cable has been manufactured from them, and found to endure the severest test to which it could be subjected. Paper has also been made from the fibre of the plantain stems which are now thrown aside to rot on the ground. One sort for writing, another quality resembling parchment, and a coarse strong article for wrapping goods, have been obtained in the very infancy of the manufacture, and there is every probability that superior paper of all descriptions, may be produced, as improvements in the process are effected. The plantain is of rapid growth, and exceedingly prolific, and demands little attention to its cultivation. Its fruit is the bread of the tropics."—(*Introduction of Report*, p. iv.)

Plantain fibres from stems six to eight months old, and also from the stems after bearing fruit, were exhibited by A. D. Vander Gon Netscher, with the following statement:

"I have had an experience of ten years in the cultivation of from 400 to 480 acres of plantains. On every acre from 700 to 800 stems are cut annually, either for the fruit, or

after having been blown down by high winds, disease or other reasons. If cultivated for fibre, I am of opinion that by cutting them down every eight months, from 1400 to 1500 good stems could be had at every cutting, or 4,500 in two years. The average weight of the plantain tree is 80 lbs., and after repeated trials I have found that it will yield 2½ lbs. clean, and 1½ lbs. of discolored and broken fibre, fit only for coarse paper, per tree; this however, by very imperfect machinery. The keeping up of a plantain estate costs about $30 per acre annually." (*Report*, p. 3.)

Plantain stems dried, from Inver Island, Demerara River, were exhibited by Daniel Blair.

"The trees were passed through the iron rollers of a sugar mill and dried in the sun. The plantain is an annual, herbaceous tree, averaging about thirty inches in circumference and from 10 to 14 feet in height. It consists of about 90 per cent. of water, containing salts and tannin in solution. All its solid parts are contained in the specimens, consisting of fibre and connecting cellular tissue. *The yield in this fibre of thousands of acres is lost annually in this colony alone, for want of a simple and inexpensive machine for separating it. The tree must always be cut down for obtaining the fruit, and the stem containing the fibre is allowed to rot on the ground. Could an efficient and cheap machine be invented, the fibre would be almost entire profit to the planter.* The banana yields less fibre than the plantain tree, and its fibre is generally tinted." (*Ib.*, p. 5.)

"Eight or nine months after the sucker has been planted, the banana begins to form its clusters, and the fruit may be gathered in the tenth month. When the stalk is cut, the fruit of which has ripened, a sprout is put forth from the root which again bears fruit in three months. The whole labor that is required for cultivating a plantation of bananas or plantains, is to cut the stalks when the fruit is ripe, and break up the earth a little once or twice a year around the new shoots. A spot of little more than 1000 square feet will contain from 30 to 40 banana plants. (*Library of Entertaining Knowledge*, p. 366.)

Although the stems of the ordinary plantain and banana

produce fibres in no perceptible degree different from those of the *Musa textilis* or *abaca* of the Philippine Islands, yet the French government, many years ago, undertook the introduction of the latter into the Islands of Guadaloupe, and Martinique, where it was found to flourish as well as in its native soil, and where it has propagated itself to a large extent. (*Annales Maritimes et Coloniales du France, fol. vi., p.* 86.) M. Perrouttel, Botanist of the French government in Guadaloupe, in the work just quoted, has given a very full account of the *abaca* of Manilla, and the mode of extracting its fibres, which, as equally applicable to the plantain and banana proper, I here translate.

"The *abaca* of the Philippines differs essentially from all the varieties of banana known. Its stem, which rises from a tuft of shoots, has a height of from 15 to 20 feet, of a dark green color, and very smooth on its surface. Its leaves are of the same color, long, and straight, with strongly marked nerves both parallel and transverse. The fruit is small, triangular, resembling abortive bananas, and scattered here and there near the extremity of the fruit-stem. It is full of black seeds, almost round, similar to those of the *gumbo*. These seeds fructify rapidly after planting, and the young plants are strong and vigorous, attaining the dimensions already indicated within the short space of eight or nine months. The plant requires a rich and humid soil, and rejoices in thick forests, at the base of mountains, where it acquires, in a short time, an extraordinary development. I have never seen it in such perfection as on the humid, yet high grounds belonging to M. de Lacharriése (Guadaloupe), notwithstanding its entire abandonment to itself, in the midst of a jungle of other plants. Only two shoots were planted here, about seven years ago, yet now the whole valley is covered with them, so as to resemble a forest. This fact proves sufficiently that the plant is robust and easily cultivated—indeed, that it can be propagated with a minimum of care, to the greatest needful extent.

"No doubt however, its regular cultivation would be beneficial in many respects, especially if the plants were kept at a reasonable distance apart, so as to permit their full

development. In the Philippines, the stems are cut down as near the ground as possible, at the moment they evince signs of flowering, that is to say about eight months after planting. The outer sheath or envelope is then stripped off, leaving the petioles that compose the stem proper. The stem is next split into two and afterwards into four parts, after which the petioles or layers are stripped off, working from the exterior. Those composing the very interior or heart of the stem are thrown aside, as being destitute of fibres of sufficient strength for economic purposes. The reserved filaments or slips are now pounded with clubs of hard wood, first on one side and then on the other, until the transversal and cellular tissues, and porous and gummy matters are expelled. After this the fibres are passed frequently through a coarse hackle, and washed many times in clear, running water, until perfectly free from all extraneous matters. They are then hung over ropes or poles to dry in the shade.

"As the fibres are not all of the same size, those being finest which come from the slips nearest the heart of the stem, they are carefully separated by hand; the coarsest being laid aside for cables, ropes, cords, etc., according to their relative fineness, while the finest are reserved for the more delicate tissues.

"In sending them to Europe for sale, the fibres are packed in bales of greater or less size. Those which are of fifteen feet in length or upwards are folded back on themselves three or four times, according to the length of the cases containing them; those of less length are folded two or three times; after which the cases are hermetically closed, in order to protect their contents from humidity on board ship.

"This is the manner in which the *abaca* of the Philippines is prepared, and it only remains to indicate the purposes for which it may be used in France.

"As already said, the coarser fibres are used to make cables, which have great solidity and durability. Ropes of great tenacity are also made from them, which are used in many ways, but particularly in rigging coasting vessels. Of the finer sort, tissues or muslins are made of great beauty, which

are very dear, even in Manilla. I had a number of shirts made from this muslin, which lasted me a very long time, and were cool and agreeable in the use. But it is especially in France that tissues of this material are best made and of greatest beauty. They receive all colors with equal perfection. Vails, crapes, neckerchiefs, robes, and women's hats, all of great beauty and high cost, as well as of wonderful durability, are among the manufactures from the *abaca* fibres. Besides these are made various articles of men's wear, such as shirts, vests, pantaloons, etc.

"Ever since this precious fibre became known in France, our vessels have frequented Manilla, returning freighted in part with the article. The quantity imported, however, falls far short of the demands of the manufacturers, and its production certainly deserves the attention of all our southern colonies. Its cultivation, as we have seen, is easy, and, as regards cost, next to nothing, and there is no reason why it should not become an important article of commerce throughout tropical America."

M. Jules Itier, special agent connected with a late French Mission to China, made a report to his government on the productions and resources of that empire, which is published in Vol. VIII. of the work already quoted. He states that the plantain shoots are set, in furrows six inches deep, and fourteen feet apart. The fibres are separated as above described, each plant yielding 42 ounces. An expert laborer can extract fifty pounds per day. M. Itier adds:

"The *abaca* cloth is almost transparent, somewhat rigid, light, and cool to the touch, and is used by the Togals for napkins, handkerchiefs, shirts, etc., of various colors. The fibres are not spun or twisted, but the threads are used in their natural state, being only tied together at their ends. They are next wound into balls, soaked for a day in hot water, dried in the sun, and are then ready to be woven."

The necessity for the introduction of some new, cheap, and abundant fibre as a substitute for cotton and linen, in the manufacture of paper, is universally recognized. Various attempts have been made to supply it from various materials common to northern latitudes, but without success.

The bark of the willow, linden, and even the common nettle, have all been called in requisition, and paper of a fair quality obtained from them, but not of sufficient excellence or in sufficient quantity to supply any considerable part of existing demands. The subject was brought up and very fully investigated in response to a prize of $5,000 offered on behalf of the "London Times," by Messrs. Smith & Son, eminent newspaper dealers of London, in 1854, for "a cheap substitute for the cotton and linen material now used by paper makers," subject to the conditions of being "practically unlimited in quantity, and in cost ten per cent. lower than the materials now used." Paper made from a great variety of substances was offered in competition for the prize, but none answered all the conditions accompanying the offer. Paper from the fibre of the plantain came nearest meeting the requirements, it being admitted that the important condition of *quantity* of fibre for its manufactnre could be met, *provided proper machinery could be devised for its economic extraction.* The quality of the paper as regards strength and fineness proved to be all that was required, and if prepared with skill, it was believed that in color and in every other respect it would prove equal if not superior to the kinds of paper now in use.

V.—The Palm Family.

There are a number of varieties of this large and useful class of trees which produce valuable fibres, and which only require proper machinery to contribute largely to commercial and manufacturing purposes.

1. *The Gommuti Sagwire, or Ejoo fibre*, from the variety of palm known to science as *Arenga saccharifera*, is produced by the splitting or decay of the leaf-stalks. To the natives of the tropics, these naturally prepared fibres are invaluable, supplying them with materials for canvass, cordage, and a variety of economic purposes. It is best known as a product of the East Indies, but a similar article is also found under the tropics in America, where it is produced from a variety of palm known to science as the *Attalea funifera.*

The tree producing the gommuti fibre, rises from twenty to thirty feet in height, and has a dense crown of leaves. (*Plate* X.) The petioles are very stout, and it is at the base of these, completely embracing the trunk of the tree, where the horse-hair like material which coöperates to render this palm so valuable, is found. Cheaper, more durable, and stronger than *coir*, it has the additional advantage of resisting moisture, for which reason it is highly valued for ropes, especially cables, from their not being liable to injury when stowed away below, wet with salt water. Underneath this naturally produced fibre, the *Gommuti* palm produces a soft, gossamer-like substance, called *boru*, used in place of oakum for caulking, etc.

To the natives of the East Indies and the Philippine Islands, this tree is invaluable. Its juice when reduced, produces sugar, and when fermented an intoxicating liquor. From 150 to 200 lbs. of sago may also be obtained from a single tree, which also furnishes from four to seven pounds of fibre.

2. *Piassava, Monkey grass, or Para grass*, and called by the natives *chiquichiqui*, is produced from a variety of palm (*Attalea funifera*) which abounds on the Amazon river and its tributaries, in very much the same manner as the *Gommuti* fibre from the Arenga palm. The tree is one of the most elegant of its family. Its stem rises from twenty to thirty feet, straight as an arrow. From the top of this springs a tuft of pinnated fronds or leaves, often nearly twenty feet in length. Before the decay of the petioles, the fibres become detached at the margins of their bases in large quantities, hanging down ten or twelve feet in tufts, whence comes the name *funifera*, rope-bearing. Nearly all the cordage used on the Amazon, is made from the *piassava* fibre, which is remarkably round, not very pliable, and often about the thickness of the small green rush. Eight hundred tons were exported from Para in 1851, to England, where it is used for making brushes and brooms. The brushes of the street-sweeping machines of London are made from this fibre.

3. *Coir or Cocoa-nut Fibre*, manufactured from the husk or

outer covering of the common Cocoa-nut, is nearly as strong as hemp, and is used in the East for cordage. The fibre is prepared by soaking the husks in water for a long period of time, not unfrequently for six months, and until they become soft. They are then dried, and beaten until the woody part falls out like saw-dust, leaving only the fibres. The cordage made from Coir is second to that from no other material. The amount of Coir rope imported into Great Britain from the East Indies, for the year 1859, was 8,238,200 lbs., valued at $392,265.

4. *The Palmetto* (*Chamaerops hystrix*) grows throughout Central America and the West Indies, both in high rocky ground, and on low, moist lands near the sea, but appears to thrive best in the former. It shoots by a simple stalk, and has maximum height of ten to fourteen feet. It is always furnished with leaves of the form of a fan, sustained by slender compressed foot-stalks. These are very tough and serve when split and parted to make baskets, bow-strings, ropes, and a thousand other objects requiring strength and toughness. No doubt the proper machinery would enable tropical residents to produce the fibre of this palm for our markets, in which its great strength and durability could not fail to secure for it a ready sale, and extensive use. Specimens sent to the Great London Exhibition of 1851, from the Bahamas, received "honorable mention."

A variety of this palm (*Chamaerops humilis*) is found in Western Asia, Northern Africa, and Southern Europe. The Arabs use its fibres mixed with Camel hair for the cloth of their tents, as also for cordage. The fibre is extensively used in France, under the name of "African hair," in the manufacture of carpets. It is used also for sails, and for this purpose it is regarded as superior to Spanish broom. It has lately been discovered that the fibres divested of glutinous matter, are extremely divisible, and may be made as fine as flax, and into what is called flax cotton. Since 1854, they have been successfully made into sail-cloth, carpets, thread, and paper.

5. *Corosol, Coyol, or Corojo Palm* abounds in dry, arid, rocky ground throughout tropical America, but particularly in Cen-

tral America and the interior of Cuba. It grows to the height of twenty feet, and the trunk is covered from bottom to top, as are also its leaves, with long, narrow, sharp, and hard spines. It produces a large cluster of nuts with a hard shell, of the size of grape-shot, from the kernel of which is extracted an oil indistinguishable from that of the Cocoa-nut. The woody exterior of the trunk covers a pulpy heart, saturated with juice of a fresh, agreeable flavor, which may be obtained by incision, called *vino de coyol*. When fermented, it becomes intoxicating like the *pulque* of the *maguey*. In times of great drought, when vegetation is destroyed, this pulpous heart is often fed to cattle. The leaves of the *coyol* are lined with a long and excellent fibre, called in Cuba *Pita de corojo*, from which ropes, cords, etc., are manufactured. The fibres are equal to those of the *hennequin*, from which they can hardly be distinguished.

6. *The Cahoon Palm* of the English, *Coroso gallinazo*, of the Spaniards, and the *attaba cohune* of botanists, is one of the most luxuriant and prolific, as well as one of the most beautiful of the palms. It lines the coasts and water-courses of Central America, and sometimes occurs in vast parks, completely covering the ground with its arching leaves, under which the traveller may pass perfectly protected from the rays of the sun. Its trunk rises to the height of from thirty to forty feet, and its leaves are often from twenty-five to thirty feet in length. Their stems are lined with fibres, which no doubt could be extracted of the whole length of the leaf, by the use of proper machinery. I am not aware that it has ever been used except by the Indians; but if really available for manufacturers, the accessibility of the palms producing it, and their great abundance would make its extraction easy and profitable. This tree produces a nut similar to that of the *coyol palm*, which grows in clusters, a single tree bearing from 500 to 800. The kernel yields an excellent oil, equal if not superior to that of the cocoa palm.

The *Ticu Palm* of the marshy grounds of the Orinoco, and the *Ita*, (*Mauritia flexuosa* or *Morriche Palm*) of Brazil, furnish abundant and excellent fibres, as well as food, drink,

building materials, and domestic utensils. Senhor Baena, in his "Chorographical Essay on the Province of Para" in Brazil, says: "There are known twenty-three different palm-trees, each yielding fruit, *fibres*, *cordage*, oil, and even spirits."

In India, the palms producing fibres are also numerous. The *gebang* palm (*Corypha gebanga*) employs thousands of boys and girls in Java in weaving baskets and bags. Shirts, fishing-nets, etc., are made from its fibres, and ropes from its twisted leaf-stalks. It is one of the most useful of the Indian varieties of the palm. The *Caryota urens*, which attains a height of forty feet and often grows to be a foot in diameter, has leaves from eighteen to twenty feet long, from which fibres of great strength are extracted. These are used for brushes, brooms, ropes, etc. The juice of the tree when reduced produces sugar. The fibre is known as *Kittul fibre*.

The leaves of the *Borassus flabelliformis* (*Plate* XI.), yield fibres, known as Palmyra fibre, as do also those of the Brazilian Carnuba palm, *Corypha cerifera*.

Fibrous materials are also obtained from the *Sagus filaris*, a Malay palm, and in Affghanistan ropes and cords are made from the fibres of the Maizurrye Palm.

VI.—The Pandanus or Screw-Pine Family.

Plants of this order are extremely abundant on the coral islands of the South Pacific and the Indian Archipelago, and also on the Isle of France. In America they are rare. In India they are extensively used for hedges. The Pandams grows naturally on arid, sandy, or rocky soils, and from the upper part of the stems shoots out numerous ærial roots, which burying themselves in the soil, serve as stays or braces to prevent the plant from being uprooted by the wind. The leaves of all these species are fibrous, and in the South Pacific furnish almost the only material for clothing, mats, cordage, bagging, etc. The fibres are white, smooth and lustrous. All the species are easily propagated, and their natural *habitat* appears to be those sterile, arid districts of the tropics which are unfit for any other useful vegetation. See *Plate* XII.

CHAPTER V.

EXOGENOUS PLANTS.*

Of the *exogenous* plants producing fibres, the Urtica or Nettle, the Malva or Mallow, and the Lilia or Lime Tree families are most important. Some varieties of the Leguminosae and Asclepia or Milkwood families also produce fibres of good quality.

THE URTICA OR NETTLE FAMILY.

"This family, in all its subdivisions, produces plants abounding in excellent fibre. One division, the Hemp sub-

* Dr. Schaeffer has made some judicious observations on the extraction of fibres from this grand class of plants, and also on the practical cultivation of the plants themselves, which are worthy of a place in this connection:

"Many plants of this great division of the vegetable kingdom are herbaceous—that is, grow with but little strength to the stem for one year, and then die down to the ground, or altogether. Even perennial plants of warmer climates may, in the milder regions of the temperate zones, become annuals. In the case of true annuals, there is no need for any great hardening of the woody tissues of the stem, as the sole end to be attained is a sufficient support for the plant until it flowers and the seed ripens. Herbaceous stems, which die down to the ground each year, are evidently designed for a similar, restricted end. In the case of perennials, which, in other climates might become, at length, woody shrubs, a single year's growth is not enough to allow of much induration of the wood cells; and hence they approach nearly to the condition of true annuals, although the tendency to produce firm wood is constantly shown. If, under either of these three heads, a plant is found which furnishes a long and useful bast, a common and well-known mode of treatment can be economically employed for the separation of the fibre. The plant is exposed to the action of the air and moisture, with more or less of fermentation, until the different tissues become separated, and even until the different cells are loosened in their adhesion, by which the harder and shorter woody fibres are broken, and in part removed, while the pliability of the bast allows it to pass through the treatment without injury. At the same time, the short and more tender cells are also removed, the latter stages of the process differing for different plants, all contributing to the complete separation of the remains of the adherent and useless types.

"Two things, then, must concur to make a useful fibrous plant, for not only must the bast be long, pliant, and in bundles of the proper size, but the wood which is

family, contains not only the well-known hemp itself, but the hop, which although not cultivated for its fibre, has been used in paper making. The Bread-fruit, or Mulberry subfamily, includes not only the different species of mulberry, but also the common paper mulberry, which, although not a native of the United States, grows readily every where. All of the mulberries are fibrous plants; but the paper mulberry is most useful. In the Pacific islands it furnishes the paper-like cloth known as *tappa*. The tough papers of Japan and the delicate papers of China are also made from it. For fibrous purposes the plant should be cultivated so as to give long and slender shoots, after the manner of the osier or basket willow.

"The most remarkable and probably the most valuable plant of the nettle family proper is that which produces the far-famed *China-grass*, described below. We have in the United States an indigenous species of the same genus to

to be rejected must be brittle, with short cells, not much hardened or not strongly adhering together. Flax and hemp are, in our own country, the best specimens of these favorable conditions, but we have other plants nearly, if not quite as well adapted to the manufacture of useful fibre; and other countries show that nature has not been stinted in her supply of materials capable of meeting one of the first wants of mankind.

"If we have been successful in communicating a clear idea of these conditions, the ready conclusion must be that differences in degree, even in the same plant, under varying circumstances, must frequently occur; the wood may become harder and greater in amount, the bast weaker and less in quantity, and the necessary inference might be drawn that judgment and skill in the culture of the plants would favorably modify these conditions. Experience, in advance of anything like an accurate knowledge of plant structure, has shown that this is true, at least for our common fibrous crops. Single stalks of hemp or other fibrous plants allowed to grow at a distance from each other, or from other plants, would furnish but sorry specimens of fibre, if, when collected, they were managed as the results of an ordinary crop. A single plant invariably shows a hard woody stem, and a coarse fibre in the bark. But when a number of plants are grown in a small space, every one knows that they grow longer, and are more slender than when left to themselves. In this way the strength of the wood is much diminished, and the fibre of the bark, if less abundant, is finer, and possibly longer. If the plant has a tendency to branch, this is prevented, for the neat preparation of fibre from a branching stem is no easy matter.

"The close cultivation of cotton, okra, and other plants, which we are accustomed to see separated from each other, would probably show a fibre in the bark far more capable of treatment by the ordinary processes than would be suspected by most persons. A knowledge of correct principles is here of the greatest advantage, when new materials are concerned. The influence of the soils and the details of the treatment of the crop are beyond the bounds of this article."

which the *China-grass* belongs, but it seems never to have been properly examined. Of our species of true nettle, one, which is an introduced plant, has been employed in Europe for fibres. In the Western States, before the cultivation of the soil for anything except articles of food had been commenced, nettles of spontaneous growth were used as a substitute for flax, and we have often seen persons who remember the time when shirts were made from nettles. We cannot learn whether attempts have been made to cultivate these plants."*

China-grass or grass-linen, sometimes called *Caloee* or *Rhea hemp*, is obtained from the snowy nettle, the *Urtica* or *Bœhmeria nivea*, a plant abundant in China and India, and which, it has been proved by experiment, can be cultivated without difficulty in the United States. It was described early in this century, by Dr. Roxburgh, under the name of *Urtica tenacissima*. It derives its specific name from the white color of the under side of its leaves. Although for many years gradually increasing in commercial importance, it was not until the London Exhibition of 1851, that the fibre of this plant obtained the notice of the public generally. It was then exhibited in every condition, from the crude article to the woven fabric, showing a fibre of such beauty and strength, that three prize medals were awarded to different persons for specimens in the prepared state. Of the value of the fibre, no better evidence can be given than that of Dr. Royle, who states that, as imported into England, it has sold at from $300 to $400, and even $600 a ton. In respect of strength, it has been proved by numerous experiments that it sustains a weight always much greater and sometimes nearly double that of the best Russian hemp. The cloth made from the fibre, known as grass-cloth, is not unlike silk in appearance, and has a softness and strength distinct from that of the fabric of any other fibre.

The plant seems to be easy of cultivation, and three crops a year may be taken at intervals of about two months, the second growth yielding the finest fibre. The treatment of

* Dr. Schæffer, Report of Patent Office, 1859, Agricultural, p. 387.

the crop varies, but in general resembles that of hemp, except that the fibres are peeled from the stalks by hand, and then exposed to the dew by night and the sun by day, avoiding rain. In other cases they are soaked in lime-water, or boiled in a slightly alkaline solution; sometimes again the fibre is spun and even woven before it is bleached. The plant is now cultivated largely in various parts of India, and bids fair to become a most important article of commerce. Archer, in his "Popular Economic Botany," observes of it: "At present our mode of extracting the fibre is not sufficiently perfect, but we are making rapid improvements, and may hope that grass-linen, equal in quality to that of China will ere long be as cheap and plentiful as that made from flax."

In the London Exhibition of 1851 were exhibited fibres from the Neilgherry Nettle (*Urtica heterophylla*), as also from the *U. cannabina*, which furnishes fibres fit for cordage, and the *Bœhmeria puya* which gives the *Pooale* or *Puya flax* of Nepaul and Sikkim.

There is a variety of this plant (*Urtica baccifera*) indigenous to Cuba, where it is known as *Chichicaste*. It is chiefly found in the Western departments of the island, growing in rich soils. The stem rises to the height of from nine to ten feet, and is about two inches in thickness, covered with prickles. Its leaves are green on their upper surface, but paler beneath, with needle-like spines marking their veins, rendering contact with the plant most distressing. Its bark yields a strong fibre, which is used locally for cordage.

The *Ficus indica*, called *Jaguey* in Cuba, and *Mata-palo* (Kill-tree) in Central America, sometimes primarily parasitic, often attaining gigantic size, sending down trunk after trunk to the ground like the banyan tree of India, and always vigorous, produces a strong bark, from which a tough cordage of good quality and but little affected by the weather, is often manufactured. The measuring cords of the Spanish surveyors are generally made from the fibres of the *jaguey*.

II.—The Malva, or Mallow Family.

The plants of this family are known throughout the world for their excellent fibres. They are not only very numerous, but differ very widely in appearance. Some are herbaceous, while others are arborescent. Both varieties produce useful fibres.

1. *The Mohoe, or Mohaut tree,* (*Hibiscus arboreous* of Seeman,) is abundant in many parts of the tropics near the sea, and for considerable distances up the rivers. It grows to the height of from sixteen to eighteen feet, and throws out large flowers of a yellow or saffron color. Its bark is tough, not much, if at all inferior to hemp for many purposes; the fibre is naturally white, and of a soft, filamentous texture, and apparently admirably adapted for the manufacture of paper. It is now used locally for making ropes, which are in no way inferior to those of hemp in strength and durability. In Central America, the trunk of this tree, which is nearly as light as cork, is used in making rafts for floating logwood, etc., down to the sea.

2. The *Hibiscus tiliaceus*, or the *Majagua* of Cuba and Central America, also produces a valuable fibre much used for ropes. It is little affected by moisture, and hence is chosen by surveyors for measuring lines, etc. It is found usually near water-courses and the sea-side, and is consequently sometimes called *Majagua de playa.* This plant is diffused over the tropical and sub-tropical regions of both continents.

Sir J. E. Smith describes this as "One of the most common trees in every part of the East Indies, thriving in all sorts of situations and soils, and cultivated for the sake of its shade, even more than for the beauty of its flowers, in towns and villages and by the road-side. A coarse cordage is made from the bark; the wood is white and light, useful for small cabinet work, and the mucilage of the whole plant is applied to medicinal purposes."

3. *The Sunn, or Sunnee hemp of India.* There seems to be two kinds of fibres produced in India under this name;

one from the *Hibiscus cannabinus* of the *Malvaceæ*, and known to commerce as *Brown Indian hemp*, *Ambari*, *Palungeo*, etc., and the other from the *Crotalaria juncea*, of the natural order of *Leguminosae*, and called *Shunum*, *Taag*, *Goni*, etc. The *Hibiscus cannabinus* is not confined to India, but is equally found in Brazil and tropical America. In Cuba it is called *Cañamo de Senegal*, or *Cañamazo*, and the cloth made from it *coleta*.

4. The *Hibiscus esculentus* is found in Cuba, where it is called *Quimbombo* or *Molondron*. It grows freely in all kinds of soil, and produces a fibre applicable to the same uses with the flax of Europe. It is known in the United States as *okra*, and it is believed if the plants were grown closely together, the bark could be usefully treated for its fibres.

Of the malvaceous plants of the United States, Dr. Schaeffer observes: "A great many of these in the southwest are popularly unknown, but a trial of their capacities will be a great public service. Our great staple, the common cotton, is obtained from the wool on the seed, and is therefore not a bark fibre; but as the cotton is a malvaceous plant, its bark might be supposed to be a good fibre. This has been verified, as shown in the Patent Office Report for 1854. But the cotton in other regions grows to be a tree, and if we allow it to produce seeds abundantly, as it must do, to afford an abundant crop of the wool which clothes the seeds, the stem will, as a matter of course, become hard and woody. No one can imagine that there would be profit in cultivating the cotton for the fibre of the bark, at the sacrifice of the more manageable and valuable product attached to its fruit. But the *okra*, which is only raised for its esculent, immature seed-vessels, seems much better adapted to profitable employment in this direction. The fineness and abundance, as well as the strength of the fibre, are such as to render experiments with this plant under close cultivation highly desirable. From specimens in our own collection, it would seem probable that the quantity of fibre on a single plant might, under favorable circumstances, be sufficient to pay for the process of stripping it by hand.—(*Patent Office Report*, 1859. *Agricultural*, p. 387.)

III.—Tilia, or Lime Tree Family.

The principal varieties of this family are found within the tropics, forming weed-like plants, shrubs, or trees, with handsome, usually white or pink flowers. A small number are peculiar to the northern parts of both hemispheres, where they form timber trees. Among these are our lime or linden (vulgarly, *bass* or *bast-wood*) trees.

1. The inner bark of the linden (*Tilia Europea*) is tough and fibrous, and from it are manufactured Prussian mats.

2. *Jute*, or *Jute hemp*, is produced from the bark of a member of this order, the *Corchorus capsularis*, which is cultivated to an immense extent in India, particularly in Bengal. It is also found in Brazil, whence small quantities are exported. It is an annual plant, growing from twelve to fourteen feet in height. The fibre, which has of late years become so generally used that it rivals flax and hemp as a commercial product, is usually about eight feet long, fine, and of a remarkably satiny lustre. It will not stand wet well, and hence is not adapted for cordage or canvass that requires to be exposed to the weather. In India it is chiefly used in making coarse canvass, called *gunny*, of which bags and bales are made for packing raw produce. In England it is often mixed with hemp for cordage; and is even mixed with silk in the manufacture of cheap satins, in which it almost defies detection. Its principal use is in making coarse cloth for bagging, and in making the foundations of cheap carpets, mats, etc. The amount of *Jute hemp* imported into England from the British East Indies, for the year 1855, was 520,964 cwts., valued at $2,159,830. The amount imported into the United States for 1860, at the custom-house valuation, was upwards of $2,000,000.

Besides direct importations, a large quantity of gunny cloth is sent from the East Indies in the form of envelopes, for other materials, such as nitre, coffee, etc. Owing to the great cheapness of the gunny, the bags are rarely used more than once before they fall into the hands of the rag-merchants and paper-makers. In this condition they constitute

the cheapest paper-stock to be found in the market. The demand for it, however, has not been extensive, even at low prices, as it is impossible to bleach the fibres sufficiently to render them serviceable for the manufacture of white paper. This is owing to the fact that the bark of the tree producing the gunny, contains a large quantity of humic and cremic acids, together with some mineral bases, and some tannin. These substances rapidly neutralize and destroy almost any bleaching agent which can be applied. The use of gunny is, therefore, wholly restricted to the manufacture of brown wrapping and envelope papers.

3. The best and whitest rope used in the Isthmus of Panama and many parts of South and Central America is made from the fibre of a member of this family, the *Apeiba Tiborbon* or *Corteza* of the natives. In Cuba there are a number of plants and trees of this family known under the name of *Guisasos*. The *Guisaso de caballo* (*Triumpheta semitriloba*) produces a good fibre used for cloth, ropes, etc. Other varieties are said to equal it in this respect, but the best fibre is obtained from the *Guisaso del cochino* (*Triumpheta lappula*).

IV.—Yucca, Liliacea, or Lily Family.

This is a large and useful family of plants. Some are showy garden flowers, such as tulips, lilies, tuberoses, etc., while others produce medicines, among which the aloe is conspicuous. Others still produce fibres of good quality, and to these we confine ourselves. Five varieties of these, the *Yucca, angustefolia*, *Y. gloriosa*, *Y. aloifolia*, *Y. recurvifolia*, and *Y. filamentosa*, are all native in the United States, abounding in the regions bordering on Mexico, in Western Texas, New Mexico, etc. The *Y. aloifolia* (represented in *Plate* XIII., in flower), and the *Y. gloriosa* (represented in *Plate* XIV., before flowering), are both frequently called Adam's needles, Spanish bayonet, Petre, Dwarf Palmetto, etc. The *Y. filamentosa*, (represented in *Plate* XV., before flowering,) is commonly known as Bears' grass, Silk-grass, Eve's thread, Everlasting, etc. They all flour-

ish in the poorest soils, and might be propagated in almost all parts of the United States. Nutall, in his catalogue of North American plants, mentions the *Y. filamentosa*, and *angustifolia* as found on the banks of the river Missouri from the confluence of the river Platte to the mountains. The *Y. gloriosa*, he adds, is called *Petre* by the Mexican Spaniards, "and is used for cordage, ropes, etc., as well as for packing cloth, and is extremely durable." Of the *Y. filamentosa*, Elliot, in his Botany of South Carolina, says, "It appears to possess the strongest fibres of any vegetable whatever, and if it can be raised with facility, will furnish a valuable article of domestic economy."

That all these varieties can be made available by the new machinery referred to in this memoir, may justly be inferred from the uses to which the kindred plant, the *Phormium tenax*, which yields what is known to commerce as *New Zealand flax*, is applied. *Plate* XVI. represents this plant in flower. It can scarcely be distinguished from the yuccas of our own country, by the uneducated eye. The fibre is now extracted from the long leaves by drying, maceration, and hackling. The coarser qualities make good ropes, and very fine linen is manufactured from selected fibres.* Specimens of hemp equal to that called New Zealand, was sent to the London Exhibition from the Behamas, manufactured from the *Yucca serrulata.*

Morgahee, *African Hemp*, or *Bow-string Hemp fibres*, were exhibited in the London Exhibition of 1851. They are prepared by hand from the leaves of a plant of this order, the *Sanseviera zylanica*, which is found over the tropics of India and Asia.

* In the report of the great Exhibition in London of 1851, it is stated that the mode adopted for extracting the New Zealand hemp is as follows: "The plants are soaked for two days in water, then twisted into hanks, and beaten with a mallet, the extraneous matter being washed out, leaving the fibre." The plant producing this hemp has been acclimated in the South of France, and in Algeria. It has also been introduced into South Carolina, and other Southern States, where it flourishes and propagates itself in a wild state.

V.—Leguminosae.

The plants of this order are almost innumerable. De Candolle gave 2,360 species as known in his day, of which upwards of 1,000 were peculiar to tropical America, and 452 to the East Indies, where a number of varieties are valued for their fibres. I am not aware that any of them have been used for the production of fibres on this continent, except perhaps in Brazil.

1. *Sun, Shunum, Taag, Janapum, or Bengal hemp*, to be distinguished from the *Sunn, or Sunnee hemp* of India, (see *Malva* family,) is the fibre of the *Crotalaria juncea*, and is a valuable substitute for Russian hemp. It is coarser in quality than the *Jute hemp*, but better capable of withstanding wet. The natives of India manufacture it into all kinds of ropes, packing cloths, sacks, nets, etc. In order to improve the fibre the plants are sown as closely as possible, and thus grow to the height of about ten feet. Dr. Buchanan (*Journey*, Vol. I., p. 226–7, 291, etc.) states that the plant thrives best on poor sandy soil, but requires to be abundantly watered. When cut down, it is spread in the sun and dried, the seeds beaten out, after which it is tied up in large bundles, and stacked under sheds. When wanted, the stems are macerated from six to eight days, or until the bark separates readily from the pith. They are taken up in handfuls, beaten on the ground, and washed until clear of the pith, after which they are dried, and beaten with a stick to separate and clean the fibres, which are then ready for spinning. If taken green, and worked by Mr. Mallory's process, the fibre would be white instead of brown, and probably double its present value, which, in India, is from $50 to $60 per ton. An acre of the plant is estimated to produce about 600 lbs. of the cleaned fibre.

Besides the fibres of the plant here described, those of a large number of other plants of the same family were exhibited by Dr. Royle at the great London Exhibition of 1851.

Strings and ropes of the fibre of the *Bauhinia racemosa*, called *Patwa*, from Bhagnepore.

Yercum fibres from the bark of the *Calotropis gigantea.*

Fibre from the stalks of *Parkinsonia aculeata.*

Pulas cordage from the fibres of the inner bark of *Butea frondosa* (a fine tree.)

Duchai hemp, fibre of *Æschynomene cannabina.*

An arborescent member of this family, *Lonchocarpus tenax*, is found in Cuba, where it is called *guama.* It grows to the height of from thirty to forty feet, and is nine inches in thickness. Its bark furnishes good fibres used for cordage and cables. There is another variety in the island known as *Guama del costa* (*Lonchocarpus siriceus.*)

No doubt most, if not all of the above fibre-producing plants are diffused over tropical America.

Asclepia or Milkweed Family.

The ordinary milk-weed or silk-weed (*Asclepias cornuti*) is so well known as hardly to need a description. The abundant and beautiful "silk," on the seeds in its pods, however, is susceptible of but few useful applications, inasmuch as the hairs are cylindrical and perfectly smooth, and therefore incapable of taking that hold on each other necessary to being spun into thread. The bark of the plant nevertheless contains a fibre, which was once regarded as of sufficient value to induce its introduction into Europe, and its cultivation there. Here, however, the plant has been entirely neglected, although it appears that a patent for extracting its fibre was granted in 1834 to Mrs. Margaret Gerrish. The fibre is long, nearly as strong as that of hemp, but firmer and more glossy, while the quantity from a single stalk is nearly the same. Dr. Schæffer says of it, "The culture of this plant is said to be without difficulty, and almost every one has observed it growing even on the poorest soils. As it is perennial, with strong roots, successive crops might, for a long time, be obtained from one sowing of the seeds. * * The fibre may be ranked between that of hemp and of flax for textile purposes, while, if the commercial demand for such

uses were not sufficient, its cultivation for paper stuff, at once, might prove remunerative."

Several varieties of this family are used in India for supplying fibres. One, furnishes the very tenacious fibre known as *bow-string hemp;* another, the *Orthanthera viminea*, grows luxuriantly along the bases of mountain ranges, and its long, straight, slender, and leafless stems fit it particularly for supplying materials for cordage.

Yercum-nar is the name given in Bengal to the fibres of a plant of this family, the *Calotropis gigantea*, which are believed to be the most tenacious of any known in the world. (See Tables, p. 22).

Miscellaneous Plants.

Besides the various plants of the several families already described, there are numerous individual plants which produce fibres, but which it would occupy too much space to notice in detail. Among these may be mentioned the Girasole or Jerusalem artichoke, (*Helianthus tuberosus*), and a still more familiar member of the same family, the common sunflower (*Helianthus annuus*). It is said that the latter yields four kinds of fibre of different qualities and thicknesses. A patent was obtained in England in 1856, for extracting the fibres of this plant by machinery.

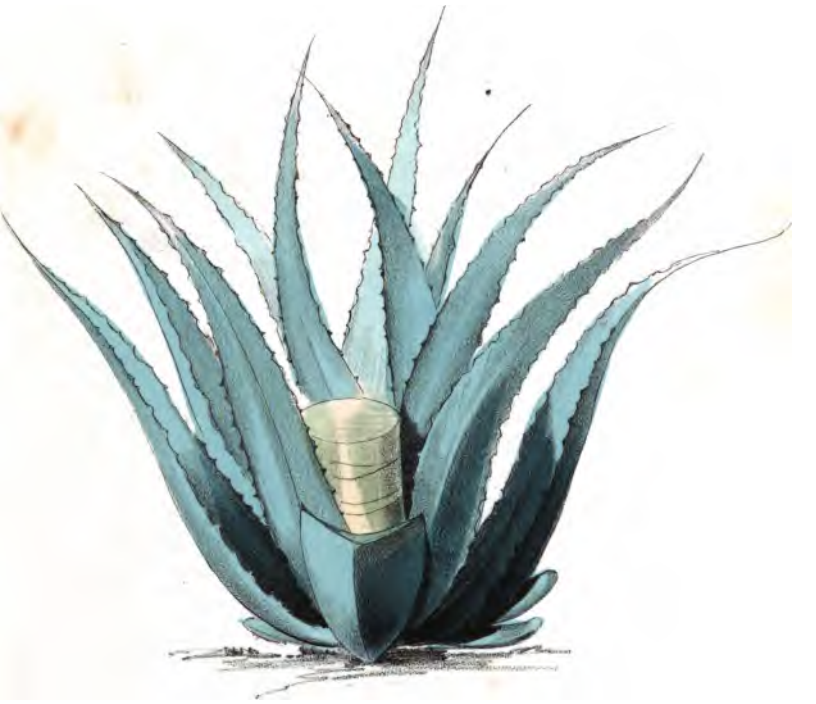
The *Apocynaceæ* or Dogbane family is represented in various parts of the world by plants remarkable for their fibres. Two of these in the United States are rather well-known for their medicinal properties and their fibres. One of these, the "Indian hemp," (*A. cannabinum*) has its properties represented both by its common and its botanical name. Experiments on its cultivation are desirable.

AGAVE SISILANA.
(YASHQUI)

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

FURERÆA GIGANTEA.

LITH. OF SARONY, MAJOR & KNAPP, 448 BROADWAY, N.Y.



AGAVE MEXICANA.

LITH OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

AGAVE AMERICANA.
(CENTURY PLANT)

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

AGAVE VIRGINICA.

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

BROMELIA SYLVESTRIS OR PENGUIN.
(WILD PINE APPLE)

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

BROMELIA KARATIS .

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

BROMELIA ANANAS
(PINE APPLE)

LITH OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

MUSA ROSACEA.
(BANANA OR PLANTAIN TREE)

LITH. OF SARNEY, MAJOR & KNAPP, 340 BROADWAY, N.Y.

ARENGA SACCHARIFERA.

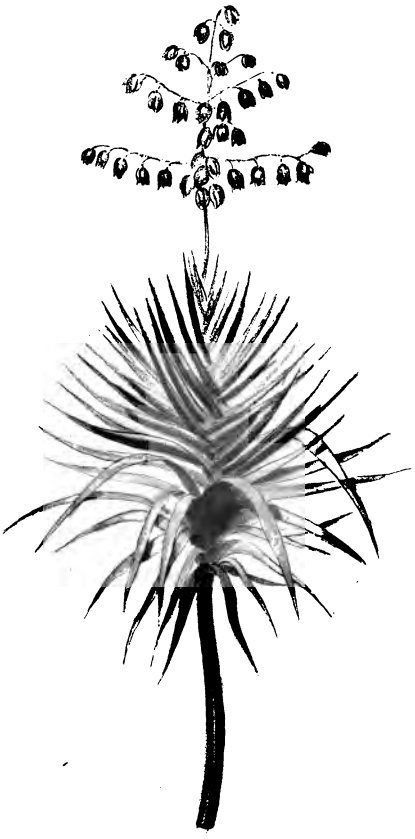
LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

BORASSUS FLABELLIFORMIS.

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

PANDANUS ODORATISSIMUS.

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.



YUCCA ALOIFOLIA

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

YUCCA GLORIOSA.
(SPANISH BAYONET)

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

YUCCA FILAMENTOSA.

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.

PHORMIUM TENAX.
(NEW ZEALAND HEMP)

LITH. OF SARONY, MAJOR & KNAPP, 449 BROADWAY, N.Y.